DEPARTMENT OF
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Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

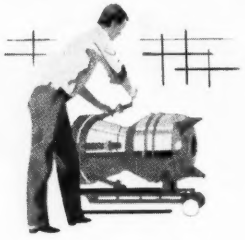
JUNE 1958

SPECIAL SECTION
ON TARGET DRONES

We Can't Conquer Space with Missiles . . . Capt. Robert C. Truax

Von Kármániana . . . . . Lee Edson and A. K. Oppenheim

Ever hear of a thirty-five header?



Tandem locomotives, teamed to pull a train up a grade, are often called a double header. It would take a "35 header" to equal the power of the RMI rocket engine shown here.

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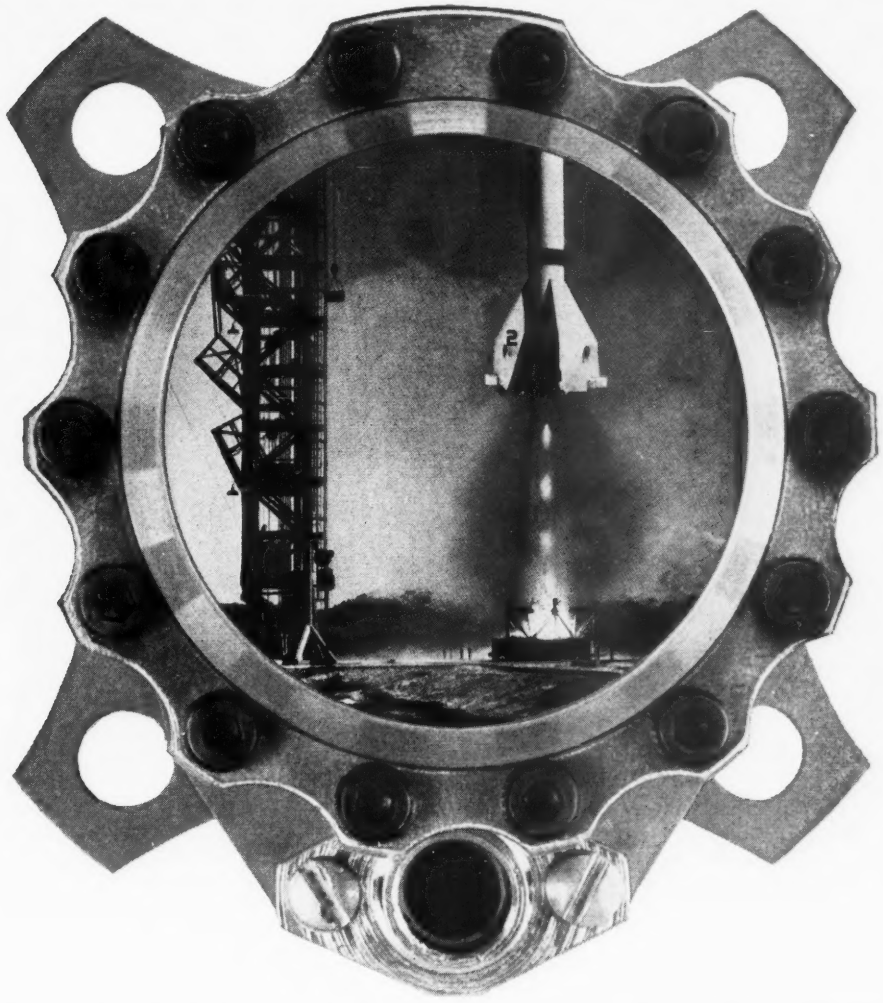
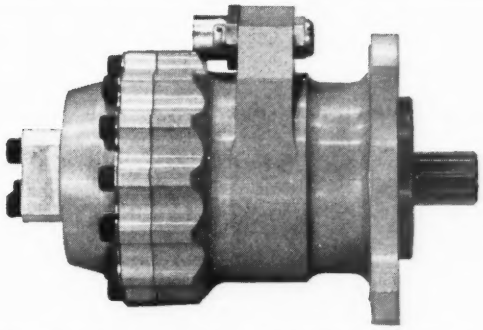


NOW you can order missile hydraulic pumps from HYDRO-AIRE



SPECIFICATIONS:

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Pressure—3000 psi
Speed—9000 rpm
Weight—21 ounces

Hydro-Aire—a name you know and rely on for quality airborne controls—announces the development of a new lightweight high pressure positive displacement hydraulic pump designed specifically for the missile industry. Pre-tested in Hydro-Aire's development laboratory, this new pump has demonstrated high efficiency performance over a life span that exceeds known missile application requirements. The unit is ready for quantity production and can be easily adapted to your particular specifications.

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VARIABLE DISPLACEMENT
3906 Series ■ Weight...2.4 lb

STANDARD
CONSTANT DISPLACEMENT
3906 Series ■ Weight...2.1 lb

- 48% weight reduction—70% smaller envelope*
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- First of a new complete line
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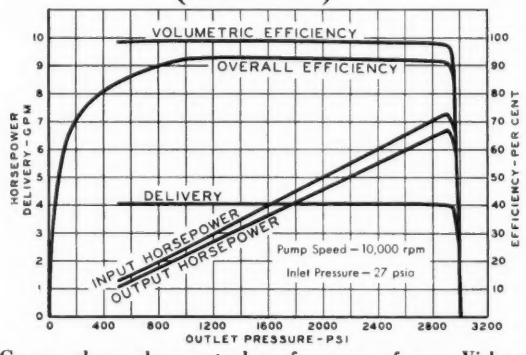
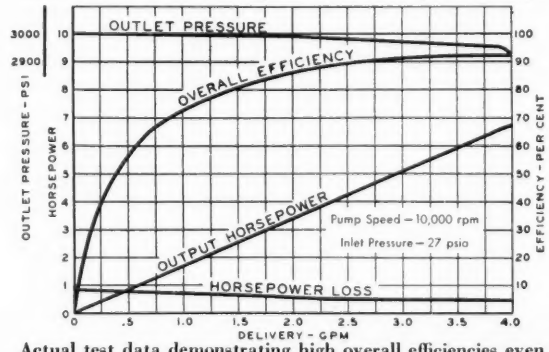
*Compared to standard 3000 psi Vickers Series PV-3906 variable displacement axial piston pump.

For further information write for Bulletin No. A-5233.

Performance Characteristics of Model E-0011111 Pump
(PV-3906 -30° Size)


VOLUMETRIC EFFICIENCY
OVERALL EFFICIENCY
DELIVERY
INPUT HORSEPOWER
OUTPUT HORSEPOWER
Pump Speed – 10,000 rpm
Inlet Pressure – 27 psia
HORSEPOWER
DELIVERY - GPM
EFFICIENCY - PER CENT
OUTLET PRESSURE - PSI
0 400 800 1200 1600 2000 2400 2800 3200
0 1 2 3 4 5 6 7 8 9 10
0 10 20 30 40 50 60 70 80 90 100

Curves above show actual performance of new Vickers variable delivery pump. Note exceptionally high volumetric and overall efficiencies throughout broad outlet pressure range.


OUTLET PRESSURE
OVERALL EFFICIENCY
OUTPUT HORSEPOWER
HORSEPOWER LOSS
Pump Speed – 10,000 rpm
Inlet Pressure – 27 psia
OUTLET PRESSURE - PSI
HORSEPOWER
EFFICIENCY - PER CENT
DELIVERY - GPM
3000
2900
0 .5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
0 1 2 3 4 5 6 7 8 9 10
0 10 20 30 40 50 60 70 80 90 100

Actual test data demonstrating high overall efficiencies even at partial flows for the new Vickers variable delivery pump. Note low horsepower loss throughout entire delivery range.

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Astronautics

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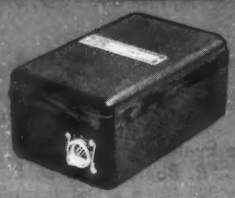

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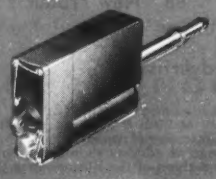

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astro notes

PROPELLANTS

• The liquid-vs.-solid battle is swinging into high gear. Solids have drawn most of the attention recently, but liquid technology is moving ahead almost as rapidly. Attention at the moment is focused on development of storable liquid propellants, which would allow liquid-fuel weapons to approach solid missiles from the standpoint of readiness. Nitrogen tetroxide (N_2O_4) is under study as a storable oxidizer, and its use with hydrazine presents some interesting possibilities. One difficulty here is that hydrazine productive capacity is still too low.

• The feeling among liquid people is that the area of storable propellants has not been explored sufficiently in this country. They note that along with development of such fuels should come development of engines which could use them. It often takes quite a bit of doing to modify an existing engine for new fuels.

• Monopropellant studies are also continuing, but interest in this area is falling off somewhat, with not too much hope held out for their use in the near future.

• While this development work goes on and progress is made, both solids and liquids suffer some setbacks. Aerojet is reported having difficulty bringing I_{sp} of Polaris solid engine to goal of 240, while Rocketdyne still hasn't ironed all the kinks out of the liquid sustainer engine used in Atlas, Thor and Jupiter.

• Although liquid advocates admire the Minute Man concept, they are not convinced systems of this type have to be based on solids, noting that the weapon could be made smaller if liquid propellants were used.

SATELLITES

• The hitherto unsuspected intense radiation band existing at altitudes of 600 miles and higher uncovered by Explorers I and III is slated for further investigation in the nine additional U.S. satellite firings scheduled for this year. Presently regarded as being sun-derived X-rays, the radiation would necessitate shielding for any living organism exposed to it for two hours. According to James A. Van Allen, planner of the IGY cosmic ray experiment, the radiation is about 1000 times more intense than cosmic rays. However, he believes it may "fizzle out" at higher altitudes, perhaps at 8000 miles.

• Otherwise, the satellites provided good news for man-in-space projects, with temperatures and meteoritic impacts found to be within anticipated ranges.

• Meanwhile, a trickling of Soviet satellite data posed several new problems for space biologists. While Laika's heartbeat increased to about three times its normal rate during acceleration of the Sputnik II launching vehicle, as anticipated on the basis of tests on earth, preliminary reports say it took almost three times as long to return to normal as was indicated by such tests. This was apparently the result of weightlessness, which seems to have affected the dog's breathing and blood circulation. A failure in the oxygen supply system is now suspected of being the cause of Laika's death.

• Soviet data also indicate that temperatures at 135 miles are higher than was previously suspected and agree with U.S. findings that atmospheric density at altitudes of 135 to 200 miles is considerably greater than was expected. The latter may be a limiting factor on close-orbit satellite lifetimes.

• Vanguard program, still beset by difficulties, will continue. Failure in electrical system lay behind unsuccessful firing in late April.

• Satellite tracking teams are becoming more and more concerned over FCC failure to provide additional frequencies for space flight missions. They point out

that, even with only three or four satellites in orbit, the two assigned frequencies become saturated. Vanguard satellites, carrying transmitter powered by solar batteries with a 10-year life expectancy, could tie up one frequency for many years.

MISSILES

• Release of first size and weight data on Titan at Camp Cooke ceremonies reportedly raised the roof at BMD and Martin Co. headquarters. Missile is 90 ft tall (about 15 ft more than Atlas), weighs 250,000 lb loaded with propellants. Weight with guidance equipment and warhead, but without propellants, is 48,000 lb. Martin is pushing for hard bases for the missile.

• While no longer on a crash priority basis, AF Minute Man has caught the imagination of both military brass and engineers. The concept is regarded as exceptional. Main problems: Heat, noise and vibration in underground firings. Present plans call for running the project like AF ballistic missile programs, with Ramo-Wooldridge as technical director under BMD and separate prime contracts for propulsion, airframe, guidance and warhead systems. Initial R&D contracts are expected to run to about $100 million, with selection of contractors to be made on the basis of low backlogs to assure continuity of operation. R-W, fed up with systems direction, is reportedly seeking a production contract as well.

ASTRONAUTICS

• North American is seeking military backing for an ion propulsion unmanned reconnaissance vehicle. The Snooper vehicle would be boosted by chemical rockets to altitudes where the ion system could be used.

• AF Titan ICBM, now rapidly approaching flight testing, may find extensive use in space flight missions. A two-stage vehicle, it is regarded as being more easily adaptable for such missions than Atlas. It has the added advantage of being transportable in a C-133.

•ARPA, dead serious in its effort to get top people for important posts but hampered by the fact that its existence is not guaranteed beyond one year, is offering one-year, as well as long-term, positions. One-year "scientific advisers" will officially be on leaves of absence from their companies.

SPACE MEDICINE

• Mouse experiment in first flight of AF Thor-Vanguard re-entry test vehicle was planned and carried out by AF human factors group working out of BMD. The mouse lost its chance to be a hero when the first-stage engine burned out early and the second stage failed to fire.

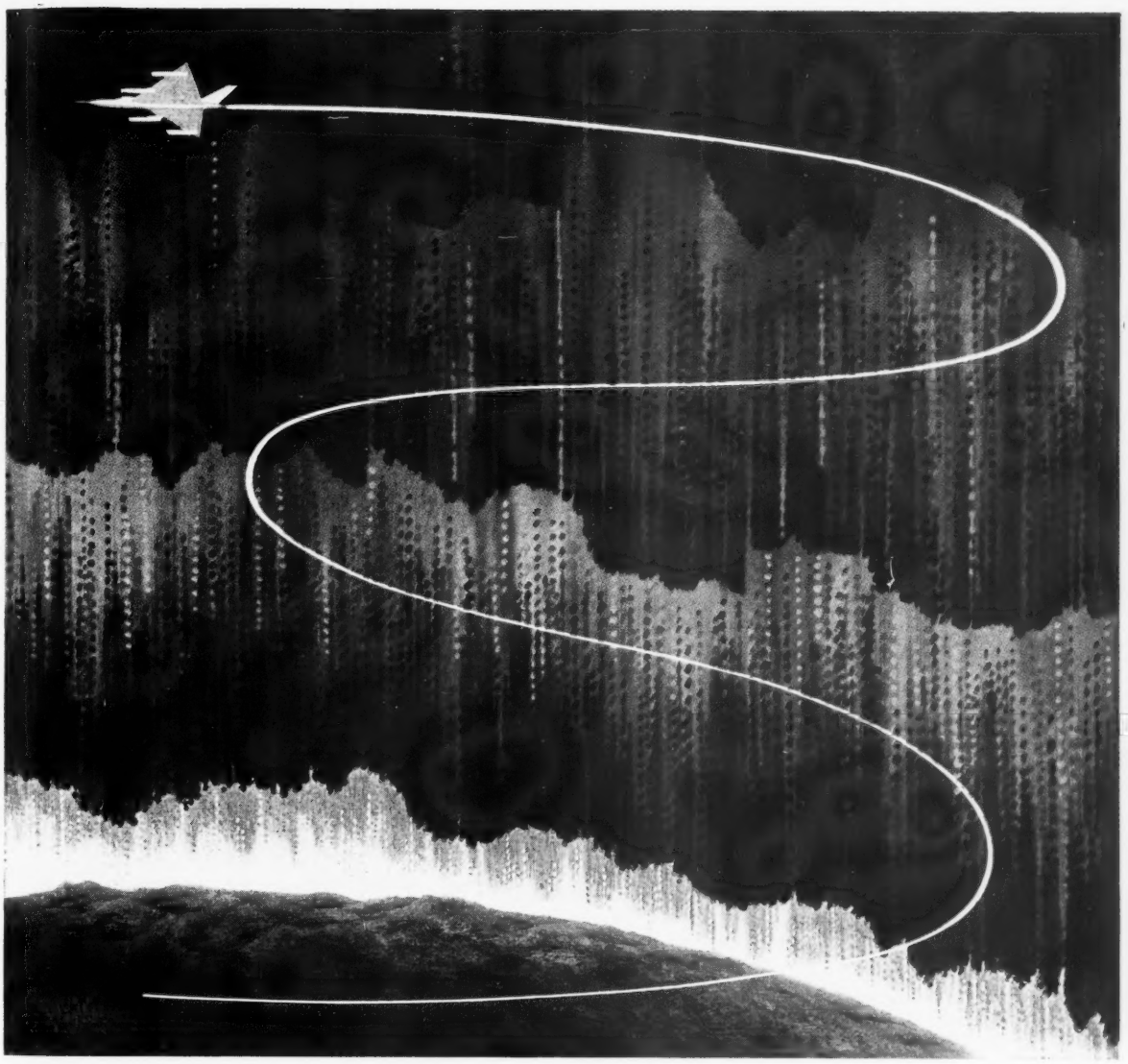
• AF will begin training of space flight crews at Edwards AFB this summer. A two-year program is planned, during which specially selected personnel will be subjected to high-G forces, weightlessness and long periods of isolation in simulated space flight missions.

MATERIALS

• Recent AGARD meeting in Rome revealed considerable research in high-temperature materials. One NATO country is reported to have developed a new alloy made up of tungsten, tantalum, niobium and molybdenum capable of withstanding temperatures on the order of 3000 C.

• Explosive forming of fairly heavy gauge tough metals in a die appears of interest in manufacturing subtly shaped high-pressure components like combustion chambers. Lockheed and Olin-Mathieson recently made a study of this process.

• Development continues on the three basic hydraulic fluids showing promise in high-temperature pumps: Silicate esters (OS-45 typical) for up to 450 F, disiloxanes (MLO-8200 typical) for up to 550 F, and silicones (Versilube typical) for possible use up to 700 F.



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News highlights from Washington

ASTRONAUTICS

• President's proposal to turn NACA into National Aeronautics and Space Agency seems assured of full Congressional backing. House Space Committee hearings have indicated strong military support for the proposal. Only fear in the minds of most Congressmen is that the new agency will be made up of aeronautical, rather than astronautical, specialists (see page 20).

• First AF satellite launching vehicle may be ready by the end of the year. Present plans call for use of an Atlas booster with a new second stage to put a 500-lb payload in orbit.

• While no final decision has been made, indications are that AF and Army lunar probe experiments will seek to determine accurately lunar mass and lunar magnetic field; to photograph the moon; and see if there is a lunar atmosphere. Attempts will also be made to impact at least one vehicle. Wernher von Braun, in testimony before House Space Committee indicated it would be "many months" before U.S. got off first moon shot, conceded Russia might beat us to it.

• Advanced versions of both Vanguard and Jupiter-C vehicles are in the works. These would permit the launching of orbital payloads of up to 100 lb.

MISSILES

• Thiokol appears likely producer of the solid-propellant engine for the Army's Pershing missile, as well as a new solid-rocket engine for an improved version of the AF Bomarc, which is expected to have a 600-mile range.

Meanwhile, The Martin Co. and Army personnel are already at work planning Pershing test areas, as well as launch pads, at Cape Canaveral.

• First firing tests of the Douglas MB-1 Genie nuclear rocket from an F-104 have reportedly already been carried out, although no official announcement of the tests has been made as yet.

• Aircraft manufacturers estimate missiles will account for at least a third of their military orders this year, against 21 per cent last year. This represents about 27 per cent of total production, as compared with 16 per cent in 1957.

• Polaris was revealed as being about 28 ft long, with base diameter of about 58 in., and weighing some 28,000 lb, including one-megaton warhead, at Navy League Seapower Symposium here. The missile will be shot from beneath the sea to a height of 50 to 100 ft by compressed air before its engine ignites. Launching tests are now being carried out near San Clemente Island, off the coast of Southern California.

NUCLEAR PROPULSION

•AEC has announced that tests of major components of the Rover atomic rocket engine will be carried out this fall at its Nevada proving ground. The tests will center on the reactor and other components, and not on the complete engine.

• While U.S. scientists now have a healthy respect for Soviet technology, reports that Russia expects to have a nuclear aircraft in the air by this summer are being received with skepticism. However, there is general agreement that our decision not to get a makeshift nuclear plane of our own in the air as soon as possible for prestige purposes may allow the Russians to accomplish the feat first.

ANTI-MISSILE MISSILES

• AF Wizard anti-missile system has been partially reactivated under a DOD directive releasing about $3 million in fiscal 1958 AF funds for use by two contractor teams, Convair-RCA and Lockheed-Raytheon, until next month, when fiscal '59 funds become available. The action reversed an earlier DOD directive assigning sole development responsibility for AMM systems to the Army, and represents a victory for AF brass, who have claimed that putting all our AMM eggs in one Nike-Zeus basket at this stage of development was ill-advised.

• Present indications are that Nike-Zeus will be a multipurpose weapon, capable of antiaircraft as well as anti-missile defense. Reportedly a scaled-up version of Nike-Hercules, Nike-Zeus will have a much larger solid-propellant sustainer engine, allowing its use against aircraft without a booster.

• Development of the Army's mobile Plato AMM system is also proceeding apace. Sylvania recently received an additional $4.5 million contract to speed development of the system, which will use Nike-Zeus.

• One of the nuclear weapon tests scheduled at Eniwetok will be an atomic blast at an altitude of more than 100 miles to determine the effectiveness of such blasts in anti-missile systems. Height of the blast will exceed that of any known nuclear explosion.

DOD REORGANIZATION

• Big hitch in President's Pentagon reorganization plan centers on Congressional reluctance to vest control of military funds in the office of Secretary of Defense Neil McElroy. A compromise seems indicated, with McElroy given authority only over R&D funds, which will amount to about $5 billion in fiscal 1959 out of a total defense budget of more than $40 billion. Both the President and McElroy are apparently willing to go along on this.

SPENDING

• The President's request for $1.5 billion increase in fiscal 1958 defense budget means military appropriations for the upcoming fiscal year will top the $40 billion mark. $218 million of the additional amount requested will go for space research programs, $206 million for construction of two additional Polaris-launching subs.

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The month's news in review

Apr. 2—President Eisenhower, in a special message to Congress, urges establishment of a National Aeronautics and Space Agency, with NACA as its nucleus and a director appointed by the President and approved by the Senate.

Apr. 5—AF successfully fires Atlas ICBM some 600 miles to impact area in Atlantic ocean.

Apr. 11—Navy reveals it test-fired a dummy Polaris missile from underwater for first time on March 23 off San Clemente Island, near Los Angeles, using a "pop-up" launcher.

Apr. 12—Naval Research Lab says Nike-Asp rockets will be used to sight total eclipse of the sun on Oct. 12.

Apr. 13—Smithsonian Astrophysical Observatory places weight of Sputnik II at several tons.

Apr. 14—Moscow says Sputnik II with dead Laika broke up this morning over Atlantic, after 2370 trips around the world, covering 62.5 million miles since its launching Nov. 3.

—Several bills to set up a National Aeronautics and Space Agency are introduced in House of Representatives.

Apr. 15—Wernher von Braun, ABMA director of technical development, reveals that Army plans to shoot a manned re-entry vehicle 150 miles into space.

—Six Navy enlisted men "take off" on a simulated seven-day round-trip to the moon at Philadelphia Naval Base.

—Lt. Gen. Donald L. Putt discloses that AF proposes to catapult a man around the world in nose of an ICBM, says this could be done in two or three years.

Apr. 16—Hugh L. Dryden, NACA director, tells House Space Committee that U.S. has around 200 projects for manned space flight, outlines how NACA expects to adapt itself to the proposed National Aeronautics and Space Agency.

Apr. 17—First fully-instrumented British Skylark rocket is fired 90 miles high at Woomera.

—Maj. Gen. John B. Medaris, Army's missile chief, calls for more forward-looking space program.

Apr. 18—Polaris test vehicle is fired at Cape Canaveral.

Apr. 19—AF Thor blows up on launching pad.

—John P. Hagen, Vanguard project director, estimates Vanguard satellite will last at least 200 years.

Apr. 20—American and Soviet scientists agree to four-month deadline extension for exchange of IGY satellite data.

Apr. 21—Hagen says satellites could be mistaken for incoming ballistic missiles, thus accidentally set off a global war.

Apr. 22—NACA announces plans to use an inflatable aluminum foil satellite for lunar probes.

Apr. 23—AF Thor-Vanguard re-entry test vehicle fails to reach intended 5500-mile range.

—Two AEC scientists tell House Space Committee nuclear-powered rockets would be able to launch space vehicles weighing 10 tons or more.

Apr. 24—AF says Thor-Vanguard nose cone traveled at least 1500 miles before its radio and telemetering equipment failed.

—Maj. Gen. Bernard A. Schriever, AF missile chief, says Pied Piper reconnaissance satellite has top priority, is scheduled for 1959 firing.

—Navy claims that a two-stage unmanned rocket sled achieved a record speed of 2827.5 mph at its China Lake, Calif., test station this week.

Apr. 27—AF reveals that a mouse was a passenger on the Thor-Vanguard re-entry test vehicle.

—AF tells Congress $16–20 million would permit five to seven shots at the moon, with a 70 per cent chance of success, by late fall.

Apr. 28—Fully instrumented, 20-in. Vanguard satellite fails to orbit after successful launching.

—James A. Van Allen asks Congress to provide at least $500 million per year for proposed NASA.

Apr. 29—Navy blames Vanguard failure on electrical system wiring, plans to launch a satellite a month for next several months.

Mark these dates for ARS national meetings:

September 15-18 ARS Fall Meeting, Hotel Statler, Detroit

November 17-21 ARS Thirteenth Annual Meeting, Hotel Statler, New York

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REDSTONE
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Sober Space Talk at Denver Astronautics Symposium

Denver, Col.—An air of "getting down to business" marked the second annual AFOSR Astronautics Symposium here late in April. Technical papers, as well as panel discussions, dealt primarily with the solution of specific problems, with speculative papers at a minimum.

Regarded by many of the more than 1000 persons attending the symposium as perhaps the most significant contribution to the technical literature during the two-day meeting was a detailed analysis of the comparative performance of ballistic and low-thrust vehicles in interplanetary flight by J. H. Irving and E. K. Blum of Space Technology Laboratories. Of major importance was the authors' achievement in maximizing trajectories for low-thrust flight.

Oddly enough, an astronomer, G. P. Kuiper, of Yerkes Observatory, got the biggest hand at the meeting, not only for the excellent photographs of the moon shown during the presentation of his very interesting paper on lunar surface features, internal development of the moon and the particle content of interplanetary space, but also for his impassioned plea for more work in the field of planetary astronomy.

Sees Need for Astronomers

Dr. Kuiper noted that today the world can only count a handful of planetary astronomers, including "one-and-a-half" from France ("a professional and an amateur") and "a half" from Italy ("a part-time amateur"). He called for the establishment of additional chairs in astronomy at American universities and for additional government and private support.

The biggest laugh at the meeting was generated by Fred L. Whipple, director of the Smithsonian Observatory, in the course of a panel discussion on manned space operations. Dr. Whipple, queried as to the cost of such operations, noted that the Egyptians are supposed to have spent about 20 per cent of their national potential for 20 years to build the Great Pyramid.

"If we spent at that rate," he noted, "we could put the Great Pyramid in space." When the laugh subsided, he hastened to add that he was not advocating such expenditures.

The panel discussion was the best attended of any of the meeting sessions, all of which produced large audiences. Panel members—Col. Paul Campbell (USAF) of AFOSR, who acted as moderator; Athelstan Spilhaus of the University of Minnesota; George Gamow of the University of Colorado; W. H. Pickering and H. J. Stewart of JPL; Paul Rosenberg of Paul Rosenberg Associates; and Dr. Whipple—were in general agreement that, for the foreseeable future at least, instrumentation could produce the type of data required just as well as a man could, if not better, considering the payload restrictions that would be imposed in putting a man in space.

This produced a cry of conservatism from well-known science-fiction writer Robert Heinlein, who took the floor at the conclusion of the panel discussion to plump for man in the exploration of space.

Earlier in the meeting, Otto Schuller of the Aero Medical Laboratory, Wright Air Development Center, in a discussion of space flight simulation equipment, stated that no attempt would be made by the U.S. to put a man in space until the mission had an 85 per cent chance of success, the same chance a test pilot has when he takes up a new jet plane.

The meeting also produced an amiable disagreement between two astronomers, Dr. Whipple and Thomas Gold of the Harvard College Observatory, on lunar dust. Dr. Gold found a recent Flash Gordon episode, which found the comic strip's hero struggling in 6 ft of lunar dust, scientifically accurate, noting that moon explorers would find the surface covered by "several feet" of dust, while Dr. Whipple, although agreeing that the moon was frequently bombarded by meteoritic particles, felt no appreciable quantities of dust would be found.

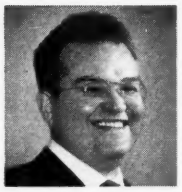
Many of the 19 papers presented at the symposium, co-sponsored this year by AFOSR and IAS, dealt with AFOSR advanced studies projects, leading one engineer to comment that the program consisted primarily of progress reports on such studies, in the field of plasma jet propulsion, thrust production by electromagnetic fields, space environment and vacuum research, etc.

Co-chairmen for the meeting were Morton Alperin, director of advanced studies, AFOSR, and Col. Paul H. Dane (USAF), chairman of the IAS Rocky Mountain Section.

The two-day meeting was followed by an unclassified field trip to the Martin-Denver facilities and the site of the Air Force Academy which attracted an attendance of over 400. A space age panel discussion for local high school students was also held during the meeting.

—Irwin Hersey

Progress in Propulsion at Marquardt



by
Roy E. Marquardt,
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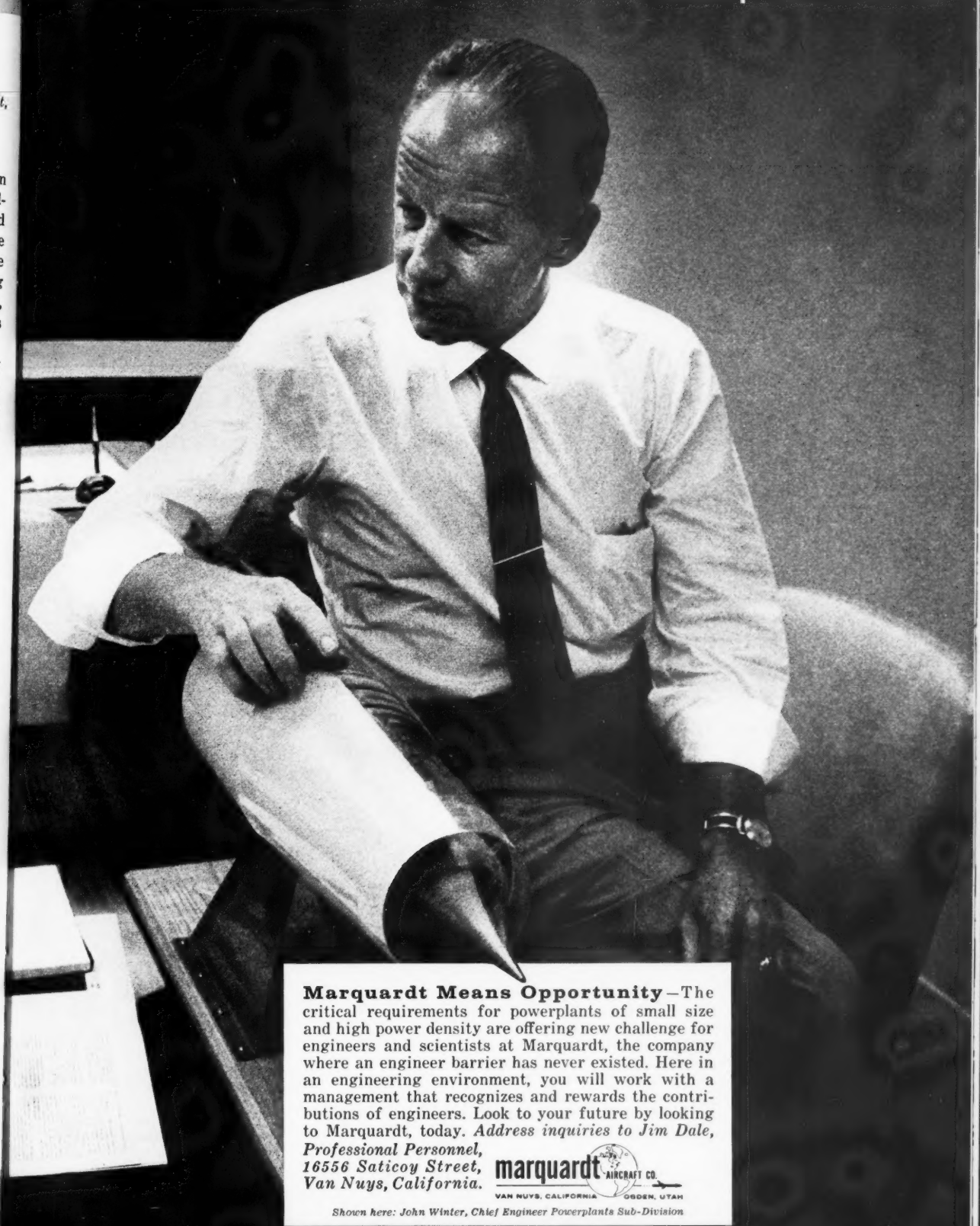

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Shown here: John Winter, Chief Engineer Powerplants Sub-Division

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Dr. H. H. Kurzweg, pioneer German rocket scientist who is now Associate Director for Aeroballistics at NOL, interprets nose-cone data obtained in supersonic wind tunnel test. U. S. Navy Photo

FROM UNDERSEAS TO OUTER SPACE—WEAPONS OF THE NAVAL ORDNANCE LABORATORY GUARD OUR FREEDOM

Basic and applied research—and the development of advanced weapons for underwater, surface and air warfare—are the vital missions of the U. S. Naval Ordnance Laboratory near Silver Spring, Md.

Established in 1918 as a small experimental group to design sea mines and fuzes, NOL has become one of the nation's most respected institutions for military research and development. Three thousand persons, including 1,000 scientists and engineers, work at its modern $50 million facility.

In its forty years, the Laboratory has made many notable contributions to science and technology, and to our national defense. In World War II, NOL-developed sea mines helped to strangle Japan's supply system. More recently, NOL's work on TARTAR, TERRIER and TALOS greatly speeded the development of these needed missiles. The atomic depth charge weapon BETTY, conceived and perfected by NOL in less than five years, now provides the U. S. Fleet a massive defense against modern enemy submarines.

Today, NOL's work embraces virtually the entire field of advanced weapons design. One highlight is the Laboratory's present key role in the development of POLARIS, the nuclear-capability missile that our submarines will soon be able to launch while submerged off enemy shores. This is one of many new weapons that NOL is developing or assisting with at present—weapons that are needed if the free world is to survive.

But in the long run, some of NOL's other work in basic and applied research may be of even more significance to mankind. For example, the advanced aeroballistics studies carried on at NOL, which already have solved some of the IRBM and ICBM problems, may help unlock the remaining doors to interplanetary space travel. Or NOL's work in advanced chemistry may provide entirely new and better types of metals, plastics and other substances. Or NOL's basic research in physics and mathematics may furnish a key to the internal structure of subatomic particles, and open up whole new worlds for science and mankind.

Thus the Naval Ordnance Laboratory aids our nation in two ways: by developing weapons that will insure the survival of freedom, and by finding new scientific knowledge that will enrich our lives. B-7

This is one of a series of ads on the technical activities of the Department of Defense.

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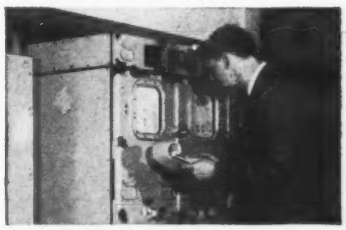

Engineer at Ford Instrument Co. checks out fire control computer developed and built by Ford for the U. S. Navy's Bureau of Ordnance.

SMALLER, LIGHTER PAM-FM SYSTEM USES LESS POWER; TRANSMITS BETTER

A report to Engineers and Scientists from Lockheed Missile Systems — where expanding missile programs insure more promising careers

Lockheed Missile Systems engineers and scientists have developed a PAM-FM telemetering system that weighs less, is smaller, uses less power, yet operates much more efficiently than conventional systems. The new transistorized time-division multiplex system is being tested for use in monitoring future flights in connection with the Division's major missile system projects.

Lockheed holds two top U.S. defense super-priority programs: The Navy Polaris IRBM, and the Air Force reconnaissance satellite. In addition, the Q-5 target ramjet and X-7 test missile programs have been expanded. Qualified engineers and scientists who join our Division at this stage in its development are thus assured better opportunities to move ahead rapidly.

Besides **Telecommunications,** positions are open in **Radar and Data Link, Antenna, Solid State Electronics, Guidance, Flight Controls, Information Processing, Ground Support Equipment, Systems Integration, Human Engineering, Reliability Engineering, Test Planning** and **Analysis** and **Aero-Thermodynamics.** If you are qualified, your inquiry is invited. Please write Research and Development Staff, Sunnyvale 14, California.

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Dr. J. W. Muehlner, Telecommunications Department Manager, left, discusses proposed packaging of the PAM-FM system with Daniel Hochman, Development Section Head.

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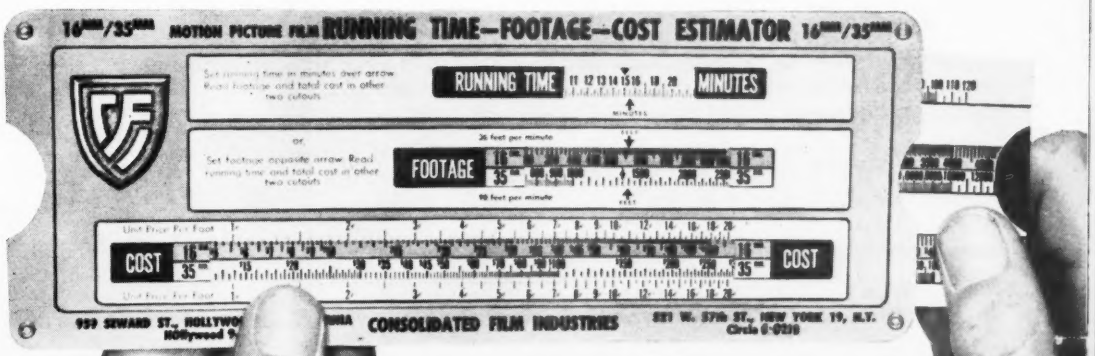

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"...AND QUIETLY BOLD"

A Message to the Scientific Community from Dr. Hugh L. Dryden, Director, NACA

NACA has pioneered in preparations for manned and unmanned space flight for the past six years and has designed and built unique aerodynamic, structural and propulsion facilities for space research. We of NACA are moving to insure that our contributions to space technology will match our record in aeronautics. It is imperative that America lead the way in the peaceful exploration of space. Our nation has the talents and resources to do the job. But we must recall the wisdom of the Killian Committee which recently said: "Let us be cautious and modest in our predictions and pronouncements about future space activities and quietly bold in our execution."

Hugh L. Dryden

Hugh L. Dryden

Hugh L. Dryden, Director, NACA; Ph.D., Johns Hopkins University

NACA has a staff of 7,750 research scientists and supporting personnel spread among its research centers on both Coasts and in Ohio. NACA staff members in pursuit of new knowledge have available the finest research facilities in the world, including several of the largest and fastest supersonic and hypersonic wind tunnels, hot jets, a fleet of full scale research airplanes, which will include the X-15, hypersonic ballistic ranges, shock tubes, a nuclear reactor establishment, rocket facilities, a research missile launching site, tracking devices, and the most advanced mechanical and electronic computers.

NACA Fields of Research Include: Analytical Dynamics, Solid State Physics, Hypersonic Aerodynamics, Magneto Hydrodynamics, Energy Sources, Propulsion Systems, Aerodynamics, Automatic Stabilization, Vehicle Configuration and Structure, Materials, Flight Simulation, Instrumentation.

A number of staff openings are becoming available. You are invited to address an inquiry to the Personnel Director at any one or all four of the NACA research centers:

Langley Aeronautical Laboratory, Hampton, Virginia
Ames Aeronautical Laboratory, Mountain View, California
Lewis Flight Propulsion Laboratory, Cleveland, Ohio
High-Speed Flight Station, Edwards, California

(Positions are filled in accordance with the Aeronautical Research Scientist Announcement 61B)

NACA

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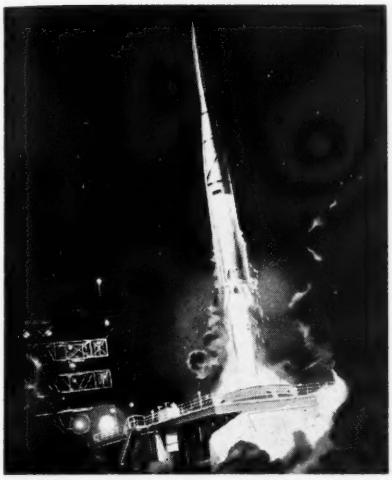


COVER: *"X Plus 15," an exciting depiction of the launching of the new Thor-Vanguard re-entry test vehicle which, with a third stage added, will be the AF entry in the moon race, by Fred L. Wolff, a new contributor to* ASTRONAUTICS.

Astronautics

JUNE 1958

The President's Letter

As any professional engineering society reaches maturity, its original objectives invariably broaden to a point where organizational changes become necessary to assure active participation by the entire membership in its activities.

Thus it has been with ARS. Formed largely as a propulsion society, ARS has grown to a point where its activities now embrace such diverse areas as guidance and instrumentation, and space law and sociology. To afford ARS members a broader opportunity to advance their particular fields by assuring closer communication between members working in these fields, seven Technical Divisions, in the fields of human factors, guidance and instrumentation, liquid rockets, propellants and combustion, ramjets, solid rockets, and space flight, each headed by a Technical Committee, were organized. Members were invited to join any two of the Divisions.

The functions of these Technical Committees are many and varied. Primarily, they are designed to stimulate the creation and submission of good technical papers in their own areas, and to review such papers and select outstanding examples for presentation at national meetings. They also plan and organize technical sessions for such meetings and appoint chairmen and vice-chairmen when necessary.

In addition, they recommend papers for publication in the society's two magazines; create subcommittees to deal with specific problems; sponsor technical reports and special publications; and represent ARS in cooperative efforts with other organizations. The ARS Space Flight Program and Education Survey are typical of committee and subcommittee activities.

The number of technical papers at national meetings and the pages of technical publications this year have more than doubled, reflecting the advantages of this committee setup. These have covered a wide spectrum of rocket and astronautical subjects.

While the Technical Committees themselves are relatively small, the Divisions are not. They have been established to provide the membership as a whole with representation in the affairs of the Society. Suggestions for new types of subcommittee activities and potential papers are always welcome. By actively participating in these Divisions, any ARS member can assure that his specific area of technical interest is not being overlooked.

George P. Sutton
President, AMERICAN ROCKET SOCIETY

We can't conquer space with missiles

An integrated national space flight program, under the direction of an agency with space conquest as its sole mission and backed up by a national determination to achieve a position of leadership in astronautics, is vital to avoid falling even further behind the Russians

Capt. Robert C. Truax, immediate past-president of ARS, is an oddity—a service man whose entire career has been spent in rocketry. Beginning with extra-curricular rocket experiments while still a midshipman at Annapolis, his enthusiasm has led him through all phases of rocketry, including design, development and flight testing of both engines and missiles, as well as program planning and engineering administration of complete weapon systems. He set up the first Navy jet propulsion section for BuAer in 1941, and established the liquid-rocket development program at Annapolis the same year, the propulsion laboratory at the Navy Air Missile Test Center and the Naval Aeronautical Rocket Laboratory. His duties have included heading rocket engine development and surface-launched missiles for BuAer, planning the AF Thor program, and planning and assisting in supervision of WS117L, the AF reconnaissance satellite. Capt. Truax is currently assigned to the Advanced Research Projects Agency, charged with development of space vehicles for the Dept. of Defense.

The opinions expressed in this article are the author's and do not necessarily reflect those of the Navy Department, the Advanced Research Projects Agency or the AMERICAN ROCKET SOCIETY.

By Capt. Robert C. Truax (USN)

ADVANCED RESEARCH PROJECTS AGENCY, WASHINGTON, D.C.

LAST AUGUST, the U.S.S.R. announced it had flown an intercontinental ballistic missile "a tremendous distance." The event created some concern in military circles but was largely ignored by the general public. On October 4, the Russians launched an earth satellite and stirred the entire nation to indignation and resolve. This resolve was not to spend more billions for guided missiles and weapons of all kinds, but to catch up with and surpass the U.S.S.R. in the conquest of space.

What has happened since then? Responsible levels of government have attempted to determine the military implications of the Russian space flight program and then to emphasize those portions of our own missile efforts that appeared, from this evidence, to be lagging. However, substantially nothing has been done toward establishing a national space flight program.

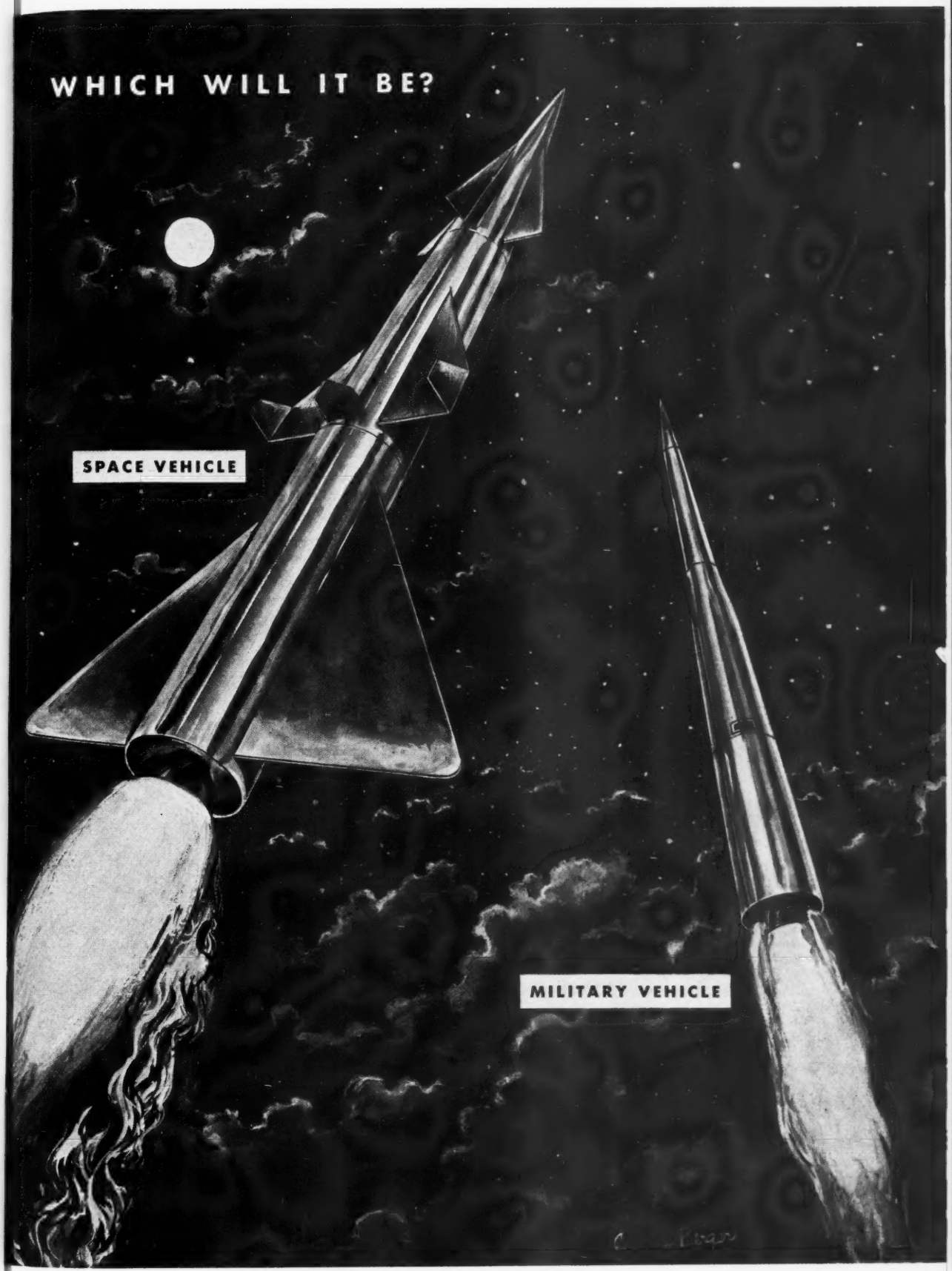
Little Done or Even Planned

The American people would be dismayed to know how little has been done or even planned. A great deal of time has been spent in educating a new echelon of advisers in the rudiments of space technology. Extra billions have been allocated to further accelerate our already frantic efforts in the ballistic missile field. Such measures now are a fantastically expensive penalty for our lack of foresight in the 1945–55 period.

Perhaps these billions will indeed improve our position in this vital area. If they do, it will be worthwhile, but you can't conquer space with ballistic missiles.

It would be as sensible to try to solve the problems of aeronautics by throwing stones into the air. Large ballistic missiles will be helpful, and even essential, in providing the initial boost to project bodies into space, but in themselves will not create the capability of man to inhabit or use this new domain.

At first glance, it might seem the soul of wisdom to rationally examine the implications of Soviet primacy in space technology and react only to those elements we can foresee as posing definite threats to our national security. Actually, such (CONTINUED ON PAGE 91)


WHICH WILL IT BE?
SPACE VEHICLE
MILITARY VEHICLE

Introducing the modern drone

As an element of instrumentation, the modern drone permits closing the loop in the process of weapon evaluation and crew training

By James F. Reagan

SPACE TECHNOLOGY LABORATORIES, A DIVISION OF THE RAMO-WOOLDRIDGE CORP., LOS ANGELES, CALIF.

James Reagan is manager of the Airborne Systems Dept. and a senior staff member of Ramo-Wooldridge's Space Technology Laboratories. He holds degrees in aeronautical and mechanical engineering, and a doctorate in engineering from the Case Institute of Technology. Before joining Ramo-Wooldridge, he was for three years manager of Beech Aircraft's Missile Division and for some six years previous to this chief engineer with the Radioplane Division of Northrop Aircraft. He has also been a research engineer with the Guggenheim Research Institute and has held academic positions with several universities, including St. Louis University, where he headed the Aeronautical Engineering Dept.

Most recently, Dr. Reagan was chairman of the Technical Session on Drones at the ASME-ARS Joint Aviation Conference in Dallas, Tex., March 17–20.

THE TARGET DRONE has come to the fore in recent years as an important element of the military arsenal, where it serves needs of both weapon-system evaluation and crew training. As an evaluation device, the drone provides a means against which the operational effectiveness of the weapon system can be assured. As a training device, it represents an enemy combat unit so that operating crews may be trained in the use of all elements of a weapon system and for maintaining crew proficiency.

To obtain a realistic simulation, the drone must be capable of the performance and maneuverability of the potential enemy aircraft and must provide the same radar and infrared appearances. Obviously, one way to accomplish this is to convert aircraft from our arsenal. Such droned aircraft have been built and many are in use today. However, there are many drawbacks to this approach. Evaluation of new weapons or training with inventory weapons should be accomplished against targets representative of the aircraft the enemy is capable of launching. Thus, aircraft droning would require the conversion of our modern operational aircraft. If one considers the quantity requirements, particularly for training missions, the cost becomes prohibitive in terms of equipment alone. Operational costs are also significant.

Maintenance Problem Complicated

Another detriment to this approach is apparent when one considers the operational problems associated with the use of droned aircraft. The ground maintenance problem normally associated with operational aircraft is further complicated by the additional equipment necessary to supplant the human pilot. Operational reliability, when extended to having a drone in the air on call, is virtually impossible to attain.

The main argument in favor of converting airplanes for use as drones is that complete physical simulation is possible. Since it is economically practical to use only obsolescent aircraft for this purpose, the degree of simulation of modern enemy equipment falls con-

siderably short of actual requirements. However, for preliminary evaluation tests, the use of such aircraft provides an interim solution when suitable target aircraft are not otherwise available.

The problem can be approached most logically by providing an air vehicle which performs and maneuvers compatibly with modern aircraft and can synthetically produce the required radar and infrared appearances. Such air vehicles can be built and operated at a small fraction of the cost of vehicles which duplicate the physical appearance of actual targets. Furthermore, it is possible to provide for the operational reliability required to support both weapon evaluation and training needs.

Target drones have other characteristic requirements in addition to those mentioned. When a drone is employed in the development evaluation of a new weapon system, it is necessary to have a reasonably accurate measurement of the accuracy of the weapon. A means must be available for measuring the trajectory of the projectile with respect to the target. Likewise, for training procedures, suitable instrumentation is needed to indicate the proximity of the projectile to the target. In other words, a "scoring" system is required.

Scoring systems have taken many forms—photographic, acoustical, electronic, etc. The drawback to most of the systems developed to date has been the time element involved in converting recorded data to useful information. Particularly in the training operation, scoring information should be immediately available to the weapon operator.

Advances in scoring systems are urgently needed to extend the usefulness of target drones and to improve the efficiency of our weapon evaluation and training efforts.

Appropriate Countermeasures Necessary

The capability of the target drone must be kept abreast of anticipated developments of enemy aircraft and missiles to prove out the effectiveness of our own weapons. For instance, enemy aircraft may make use of jamming, "spoofing," and other confusion techniques. In order to prove the effectiveness of anti-countermeasures in our weapons, the target drone should have appropriate countermeasure capabilities.

The need for target drones requires advanced planning to insure that proper equipment will be available when the time comes to evaluate new weapons or to use operational weapons in training exercises. While the lead time to develop a target drone is not so great as for a complex weapon, an attempt should be made to develop the drone approximately in parallel with the development of the weapon.

This does not imply that a separate drone system has to be available for each weapon system. Drones can be developed by type to serve weapons having similarities in their operational modes.

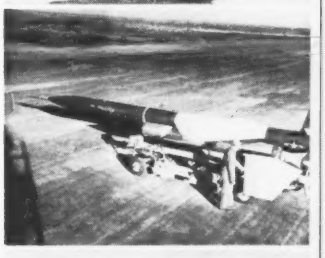
The need for early attention to future drone requirements is particularly evident in view of advances being made in weapons development. It is axiomatic that, when new weapons are available, the complete means for their evaluation and training phases should likewise be available. We must be assured that our weapons will have been proved and the operating crews properly trained for combat.

The articles which follow describe major drone design problems and suggest how these problems are being or can be solved for a variety of drone applications.

Fairchild's Surveillance Drone

Ryan's Q-2 Firebee

Radioplane's RP-76



Lockeed's Q-5

Radioplane's Q-4

Temco's Teal

Radioplane's RP-77D

Teal in action

Rocket propulsion for drones

Developed only within the past few years, rocket drones—small, flexible and economical—now bid to take over the entire field

By Arthur Sherman

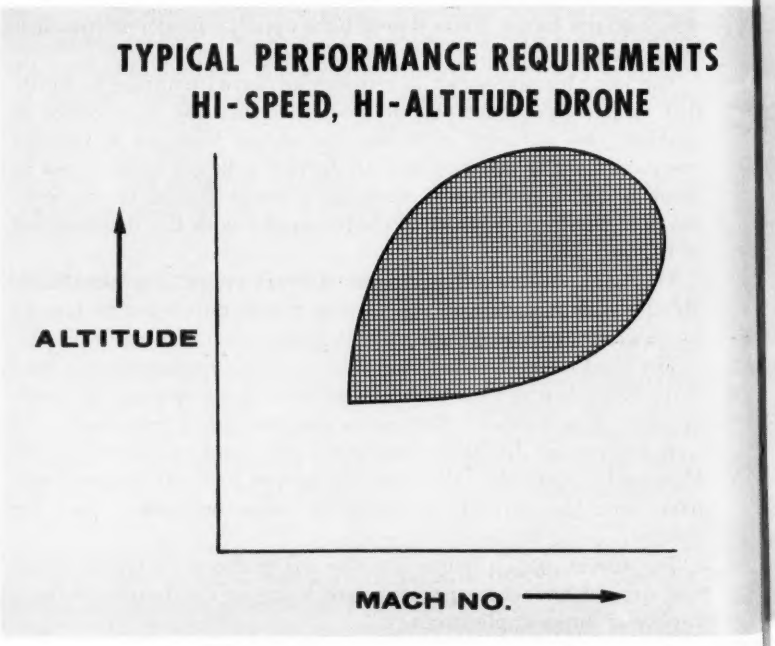
REACTION MOTORS, INC., DENVILLE, N. J.

SOME TIME AGO, when liquid-rocket powerplants were first proposed for drones, a study showed a substantial need for new drones. Many of our major weapon systems were not being properly evaluated because of a lack of targets with appropriate flight characteristics, and the older drones and converted World War II aircraft in use were entirely unsuitable for training pilots and ground crews.

Needed were small, versatile, high-performance drones—drones that were simple and inexpensive, and with modular construction which would allow them to be used individually or with other equipment and aerodynamic packages to meet a variety of operational requirements. The typical altitude-speed envelope for the expected requirements is shown on this page and is accompanied by the typical flight profile expected. The performance described by these figures could apply, in modified form, to any air- or ground-launched rocket drone.

This meant that the rocket drone required boost and sustain phases

Arthur Sherman is manager of market research for Reaction Motors, responsible for defining future trends and applications for propulsion systems and associated product and market analysis. Holder of a B.A. in mechanical engineering from the College of the City of New York and an M.S. in industrial management from the Stevens Institute of Technology, he has been a rocket engineer since 1948. He has worked on the Viking project, ROR and other important RMI projects. His interest in rocketry began at an early age. He was a recipient of the first ARS Student Award for college work—for the design, fabrication and testing of a liquid-propellant rocket engine.



of propulsion and that the propulsion system might have to perform auxiliary functions, such as attitude control, and might also have to vary thrust continuously during the sustain phase to maintain constant speed. The low-altitude, high-speed drone was more likely to use a separate, disposable booster, the powerplant simply sustaining speed. A need to vary speed, however, made desirable a motor that could also control thrust through simple pre-flight adjustments. Finally, economy might call for as many as three re-uses of a drone.

The study led to these summary requirements for a propulsion system: Step thrust (permitting use of the same engine for air or ground launching); thrust variation by pre-flight settings; high-performance; ability to be used three times; safe and easy handling; minimum production cost; off-the-shelf availability; and flexibility of installation.

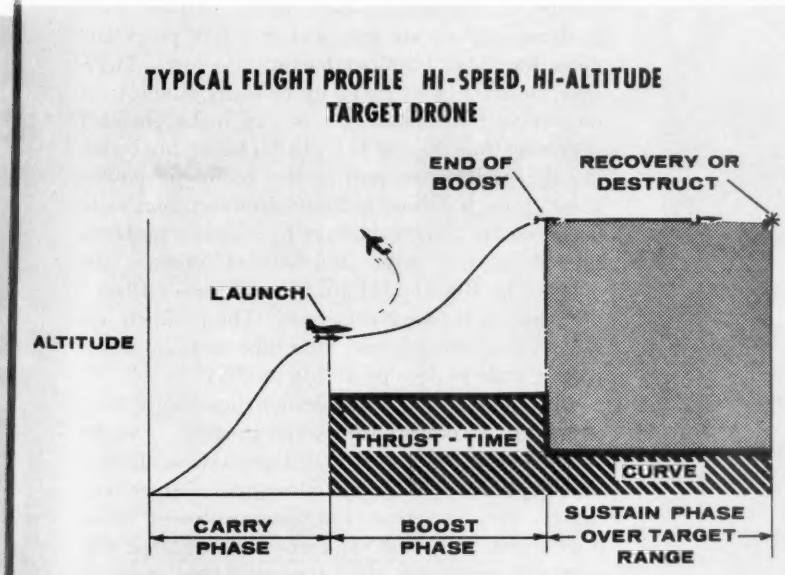
With these requirements defined, Reaction Motors studied the relative merits of rockets and air-breathing engines as candidates to meet them. Turbojets were quickly eliminated because of high cost and poor availability. Ram-rockets lacked the development background necessary to produce a low-cost motor. The ramjet, although of lower weight than a rocket for long flights, showed relatively high cost, limited availability, lack of flexibility, altitude limitations and in-flight ignition problems. The rocket appeared best.

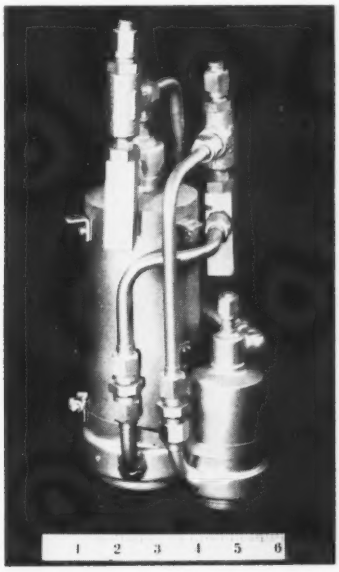
Liquid and solid rockets were then compared. The liquid rocket appeared to offer the minimum of technical and economic obstacles, and development of a liquid-propellant system was begun. It would be incorrect to create the impression that solids have not made appreciable advances in this field. They have. Several years ago, the idea that a solid-propellant engine could operate for 8 or 10 minutes would have been discarded without a second thought. Yet, today, engines of such duration are flying.

Within the past year, however, considerable progress has also been made in liquid-propellant drone engines. There are now available practical, low-cost, liquid-propellant powerplants, relatively insensitive to ambient temperatures and providing roughly 35 per cent more performance than solid-propellant motors for a given weight. Most important of all is the flexibility inherent in the liquid-propellant system, not only for one drone application but for the gamut of drones anticipated in the near future.

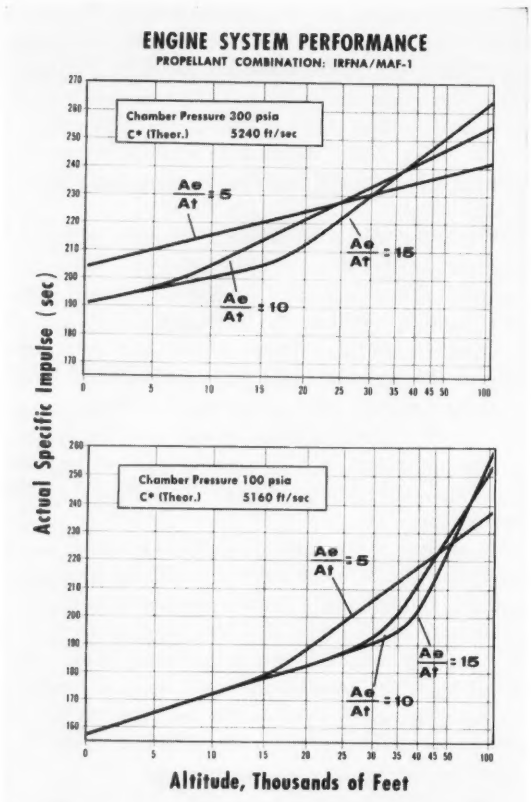
To achieve such liquid-propellant systems, much needed doing. One of the first problems was selection of propellants. Monopropellants were discarded at once because of either poor performance or handling hazards, and two bipropellant combinations were decided upon. One is a storable combination using acid as the oxidizer, while the other uses hydrogen peroxide. Each of these has its place, depending upon the mission.

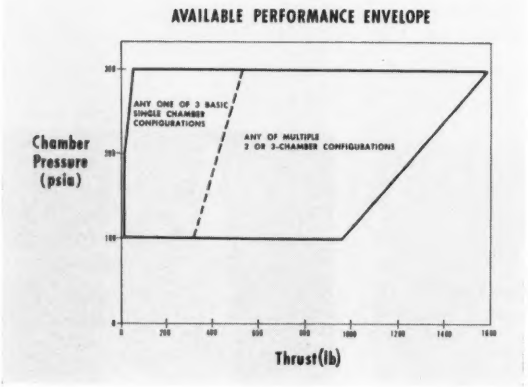
The acid system is the one RMI is using in most applications. The oxidizer and fuel may be loaded and hermetically sealed in the motor tanks at the factory or at an assembly depot. If required, they

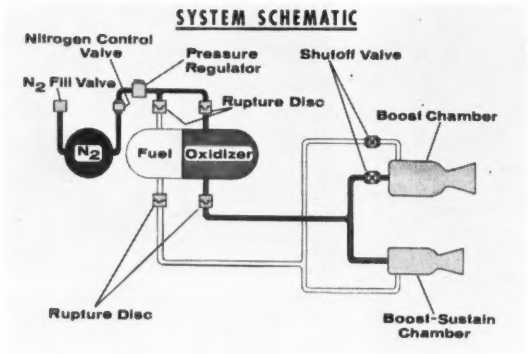




Liquid-propellant boost-sustain motor developed by RMI for drone use.




AVAILABLE PERFORMANCE ENVELOPE
ANY ONE OF 3 BASIC SINGLE CHAMBER CONFIGURATIONS
ANY OF MULTIPLE 2 OR 3-CHAMBER CONFIGURATIONS
Chamber Pressure (psia)
Thrust(lb)



can be loaded in the field without difficulty. They are storable for many years over wide temperature ranges. The powerplant can be rough-handled or subjected to extreme temperatures without serious damage or change in performance. It can be shipped fully loaded as an inflammable under ICC regulations, whereas a solid-propellant motor must be shipped as an explosive.

Performance for this propellant combination (IRFNA/MAF-1) is given at left top of this page. These figures represent actual impulses that have been demonstrated in test firings and can be obtained with production hardware.

The alternate peroxide system is better suited for drone applications requiring the powerplant to perform auxiliary functions. Such features as controlling missile attitude with monopropellant jets would make the peroxide system more costly than acid. If, however, a more complex powerplant can simplify the complete drone and reduce the overall cost, choice of the peroxide system is justified.

Multiple Thrust Chambers Used

Neglecting auxiliary functions, the design of a liquid-propellant propulsion system capable of meeting the requirements outlined would follow the schematic on this page. This system employs simple nitrogen pressurization of propellants and multiple thrust chambers, the number depending upon the boost/sustain ratio to be provided. Modularizing allows a range of thrusts with one chamber, and, by using multiples, almost any combination of boost and sustain can be achieved.

This was not accomplished easily. Thrust levels in drone engines are low, and therefore propellant flows for thrust-chamber cooling are low. Moreover, burning times range up to many minutes. A requirement for three re-uses can make chamber operating time as long as $^1/_2$ to $^3/_4$ hours, not counting the problem of putting the prototype powerplant through formal military demonstration tests. Chamber life alone would not be a serious problem; piloted aircraft with liquid-rocket engines developed by Reaction Motors provide several hours of operation between overhauls. The problem was how to provide such operating time with an engine costing little to develop and to produce.

This represented a real design-engineering challenge. In a company-sponsored program, a motor chamber was developed that appeared highly producible, and suitable for scaling-up. During testing, the very first engine ran successfully every time it was fired. This first engine has accumulated well over 4 hours of operating time, including a single run of 30 minutes. It is still being used as a workhorse test vehicle, and (CONTINUED ON PAGE 86)

Design criteria for drone rocket engines

The systems approach to mating a rocket powerplant and target drone calls for a large number of major decisions by the design engineer

By Herbert H. Isaacs and James O. Matzenauer

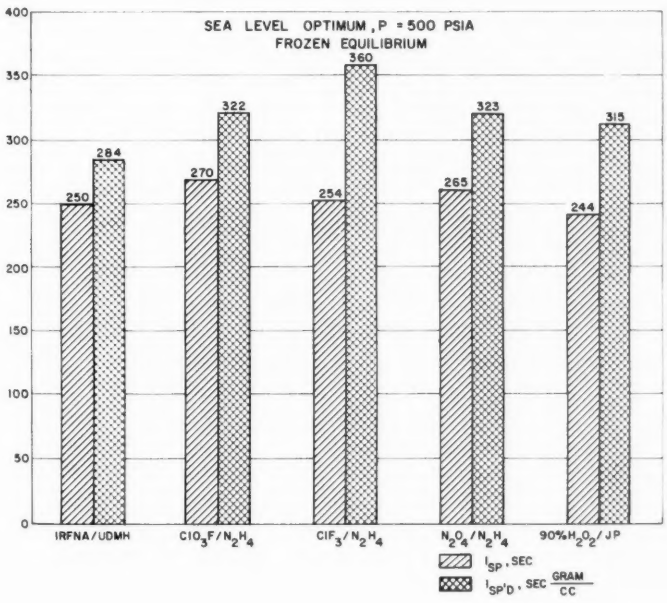
ROCKETDYNE DIVISION OF NORTH AMERICAN AVIATION, INC., CANOGA PARK, CALIF.

INTEGRATION of powerplant and airframe has been characterized historically by a compromise between application requirements and powerplant availability. As the transition was made from piston to jet engines, more consideration was given to the interrelation of engine and airframe, but choice of powerplant continued to be limited to two or three engines for a given application.

For rocket-propelled vehicles, however, powerplant selection is a more complicated task. A great variety of different systems may suit a particular requirement, and new designs, tailored to specific applications, may be developed in compatible time periods.

To illustrate the systems approach in mating a rocket powerplant to a target drone vehicle, let's look at the various decisions necessary, in typical order, from the standpoint of the engine designer. As we are primarily concerned here with the target drone,

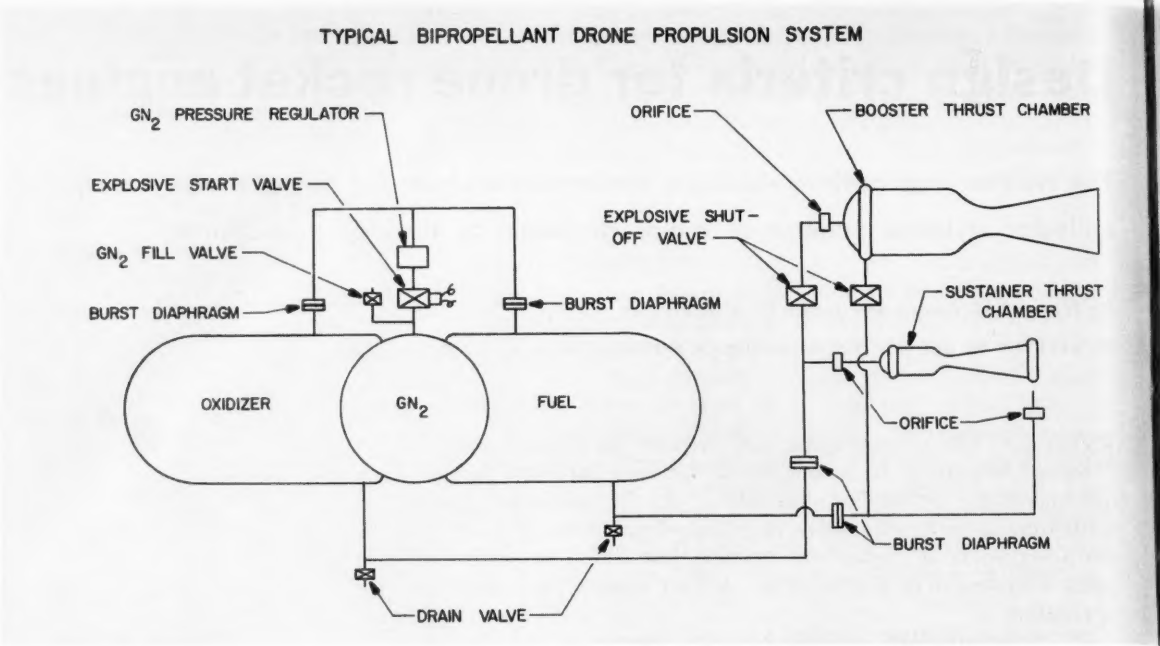
PERFORMANCE CHARACTERISTICS OF VARIOUS PROPELLANT COMBINATIONS



Isaacs Matzenauer

Herbert H. Isaacs is a Rocketdyne sales engineer, having joined the company soon after graduating from City College of New York in 1953. In his five years with Rocketdyne, he has worked on weapon system evaluation, preliminary design, operations research, and proposal preparation and negotiation. His current work entails generation of new applications for rocket powerplants.

James O. Matzenauer supervises Rocketdyne's advanced-design applications engineering section. After receiving his B.S. in aeronautical engineering from the University of Washington in 1941, he served as an officer in the Air Force until 1946, seeing duty at the Wright Air Development Center aircraft laboratory and with the Inspector General's Office, Western Air Procurement District. Before joining Rocketdyne, he was a development engineer for Douglas and a supervisor of powerplant development for North American Aviation.



Bipropellant and Monopropellant Systems Compared

Characteristics	IRFNA-UDMH	H_2O_2
Design altitude (ft)	50,000	50,000
Thrust (lb)		
Boost	120	120
Sustain	40	40
Duration (sec)		
Sustainer only	625	625
Both engines	156	156
Specific impulse at altitude (lb-sec/lb)	250	154
Total impulse (lb-sec)	25,000	25,000
Chamber pressure (psia)		
40-lb thrust	225	225
120-lb thrust	225	225
Nozzle area ratio (both chambers)	12	11
Thrust coefficient	1.67	1.64
Propellant flow rate (lb/sec)		
40-lb thrust chamber	0.16	0.26
120-lb thrust chamber	0.48	0.78
Tank volume (cu ft)		
Propellant	1.5	2.0
Nitrogen	0.36	0.37
Temperature limits (F)	−65-160	20-160
Estimated weights (lb)		
Valves, fittings, lines	7	4
Tanks	23	37
Thrust chambers	2.4	4
Nitrogen	5	5
Propellant	105	163
Total System	143	213

some of the problems investigated have reference only to this application.

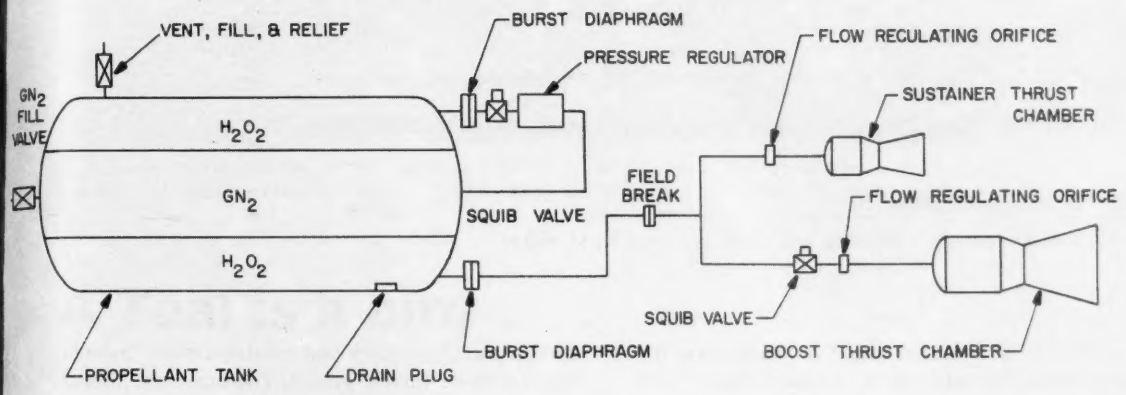
Propellant selection and engine design begin with consideration of the mission itself, which sets certain general requirements for the drone vehicle. These are minimum total program cost, reflected in both minimum hardware cost and logistic support, and flexible performance, which means the ability to adjust altitude, speed and flight time to meet the needs of different mission simulations, for both immediate and future applications.

Simplicity Means Minimum Cost

Certain general propulsion system characteristics follow from these vehicle requirements. Simplicity contributes to minimum cost in both the hardware and field support. Cheap, available components may be utilized, and development costs thus kept to a minimum. High reliability can reduce spares support and minimize costly malfunctions. On-site variations in engine performance, capability for throttling or alternate thrust levels, and potential performance growth are key factors in an expendable drone system, for they guarantee a wider scope of application and a longer service life for the vehicle.

Operation under wide environmental conditions is also required, and center-of-gravity shifts during rocket engine burning should be kept to a minimum for a simple flight system. Finally, general require-

TYPICAL MONOPROPELLANT DRONE PROPULSION SYSTEM



ments are accompanied by certain specified performance characteristics, such as thrust, duration, altitude of operation, etc.

Solid vs. Liquid Propellants

The first step in selection of propellants for a new application is the consideration of both liquids and solids. Quantitative comparisons of performance must be based on propellants available in the appropriate time period, and then qualified by considering the relative weight of the following items:

1. *Cost.* The total cost picture is a combination of development, production and support. For drone sizes, a new solid-propellant motor would require more funds for development than a liquid-propellant system. The unit cost of a liquid system, however, is somewhat higher than that for the solid. If recovery and re-use of the liquid engine is possible, the unit cost of the liquid begins to approach that of the solid.

2. *Duration.* The long durations required of the drone engine are easily accomplished by liquid systems employing regenerative cooling. There are cool-burning solid propellants capable of 8–10 min durations with an uncooled nozzle, which causes some performance degradation. Bipropellant liquid units produce over 25 per cent more specific impulse than comparable long-duration solids. In fact, there is no operational solid-propellant unit that is competitive with liquids in both performance *and* duration capability.

3. *Flexibility.* Modification of thrust levels and durations so as to vary performance at will cannot be accomplished with solid propellants. There is a limited preset flexibility possible in terms of thrust and duration programming. Once established, however, the performance profile is fixed for a given configuration. Thrust in liquid units may be varied by changes in calibrating orifices, while durations may be adjusted by varying propellant loading. Fixed throttle points for stepped thrust are easily incorporated in a liquid system.

4. *Center-of-gravity shift.* CG movement can be controlled in a liquid system by proper baffling and packaging of propellant tankage. Total CG shift in current designs has been limited to less than $^1/_2$ of 1 per cent of total length. Various arrangements of blast tubes and nozzles have been proposed for CG control in solid-propellant motors, but, in general, the task proves quite difficult, resulting in higher development and production costs.

5. *Reliability.* The solid-propellant system is less complex than the liquid-propellant system. The final criterion for evaluation, however, is the actual reliability figure as related to program length and cost. A pressurized liquid-propellant system, designed with only six moving parts, would achieve a reliability above 99 per cent. Any ultimate reliability advantage of a solid unit would be very small.

6. *Environment.* Solid propellants are generally more sensitive than liquid propellants to temperature extremes and cycling. (CONTINUED ON PAGE 66)

Drones grow with the weapon system

As aerial targets, they serve a variety of functions as weapon systems pass from research and development to operational use

By A. Fiul and P. G. Blenkush

RADIOPLANE DIVISION OF NORTHROP AIRCRAFT, INC., VAN NUYS, CALIF.

THE ROLE of an aerial target depends upon the developmental status of the weapon system with which it is associated and the objectives in testing. In research and development, the target serves as a means to verify or extend knowledge of some part of the weapon system, and the target may then be considered a part of firing-range instrumentation. During developmental evaluation, the target serves as a kind of specification which the weapon system must meet. The target serves as a training aid when the weapon goes into production. And, finally, when the weapon enters operational evaluation, the target assumes its familiar role of realistic attacker. Because of this complex of uses, several targets may be needed for one weapon system.

Interwoven elements of simulation, scoring and environment comprise the aerial target system to meet these many functions.

Simulation involves appearance, flight path, tactics and physical characteristics. Appearance of the target must cover frequencies, energy levels and viewing aspects necessary for activating intelligence devices in the weapon. The objectives of the firing program may also bear on simulation. For example, an R&D program on a guidance system may require study of system response to variations in radar size of the target or to glint, scintillation and other random variations in appearance.

Establish Dynamics of Engagement

Flight-path characteristics of most significance are speed-altitude envelopes and trajectory during engagement, which couple with those of the weapon system to establish the dynamics of engagement, and thus affect reaction times, response to evasive action, kill probability, and range of detection and acquisition.

Tactics include countermeasures, flight formation, decoys, multiple attack and evasive action. Simulation on these tactics greatly enhances the usefulness of the target.

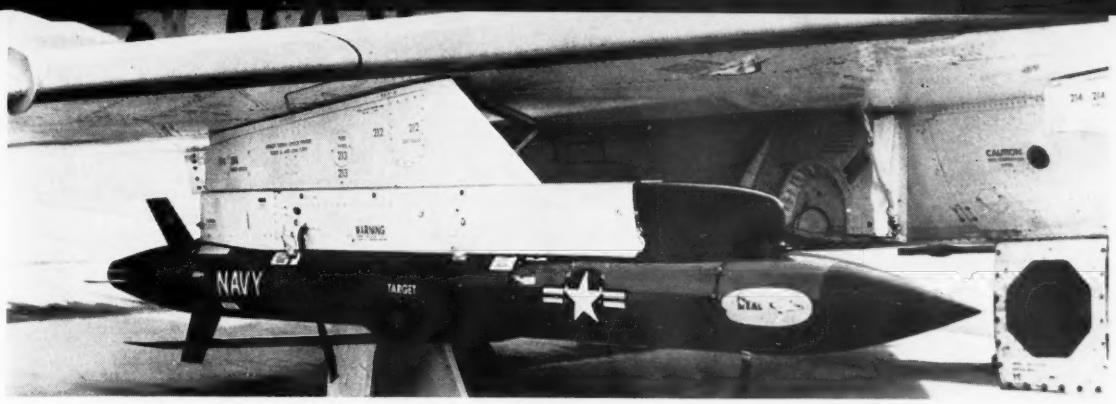
Physical characteristics include size, shape and structural considerations, size simulation being required most frequently, especially for aerial gunnery and contact-fuzed weapons. The need to simulate shape or structure is a rather special case that usually arises in the R&D phase. Target shape, for instance, may critically affect the reflection of incident energy, and structure may determine warhead lethality.

Must Record the Outcome

In addition to simulating an attacker, the aerial target must include means for recording the outcome of the encounter with the weapon system. The target usually requires instruments to record the spatial relationships between itself and the weapon during encounter, and the functioning of fuze or projectile may add requirements to scoring instrumentation. Data needed early in weapon development may include time and place of fuze actuation, relation of warhead to the target, and blast effect and fragmentation pattern on the target. Instrumentation, will, of course, involve data handling and processing. The target must either record data itself, to be recovered on flight termination, or transmit data.

In the weapon system concept, the target is employed to assure that the objectives of the weapon firing program are met as the main phases of the development cycle—R&D, developmental evaluation, and production, and operational evaluation—compress, merge and overlap under the pressure to save time.

The aerial target serves chiefly as an instrument carrier during the R&D (CONTINUED ON PAGE 60)



Teal drone, developed by Temco for Navy, ready for flight test. Teal looks like a missile, but appears on radar screens to be about the size of an attacking aircraft.

A Teal is a bird

Temco's rocket-powered target drone, now being evaluated by the Navy, can operate at up to transonic speeds and at altitudes to 55,000 ft

WORLD WAR II left the nation with large stores of surplus aircraft. Converted to drones when obsolete, these aircraft were widely used for gunnery training. However, they did not challenge present-day, air-to-air missiles and other defensive equipment. "Kills" were made too easily.

In 1955, the Navy held a design competition for a low-cost, expendable, high-performance target drone. A contract was awarded for the development of the rocket-powered drone, XKDT-1 or Teal, proposed by Temco Aircraft Corp., Dallas, Tex. This drone, now developed and being evaluated by the Navy, operates at up to transonic speeds and altitudes to 55,000 ft.

Teal, as shown here, resembles an air-to-air missile itself, but on a radar screen it appears to be about the size of an attacking aircraft. Five sections comprise its body: A fiber glass nose cone; a one-piece rolled-magnesium center section which houses an autopilot; a rocket-motor section (see page 32 for description); a cast-magnesium section containing vertical and horizontal tail surfaces and housing electrical servo actuators; and, finally, a fiber glass aerodynamic fairing and cover for a rocket-exhaust tube. Each section can be readily replaced if damaged or found to be faulty.

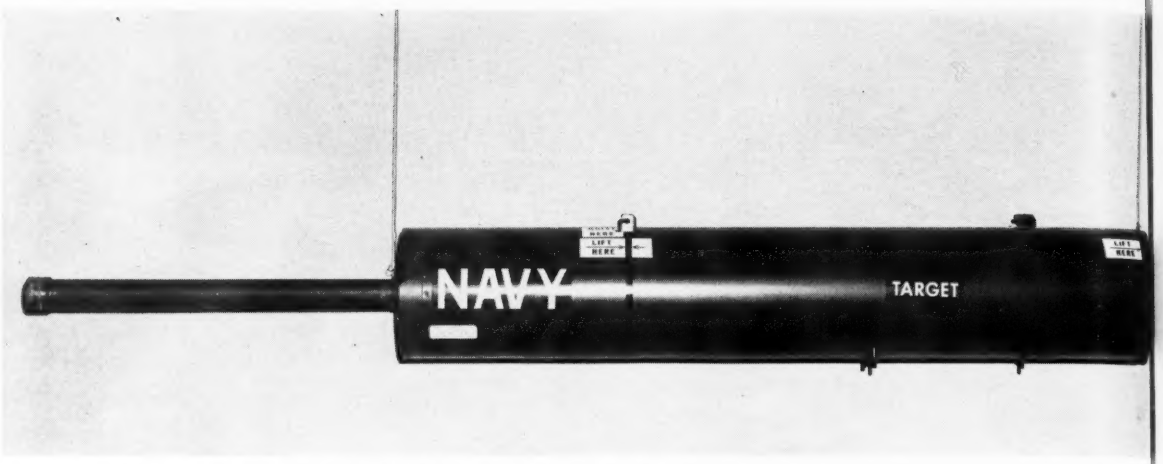
An autopilot powered by a 28-volt battery controls the heading and altitude of the drone without the aid of hydraulic or pneumatic devices. Components of the autopilot include a roll and yaw gyro, a pressure-sensitive altitude controller, servo amplifiers, a motor timer, mixing networks, and a self-destruct system which will automatically drive the drone to earth if it deviates too much from a preset course.

Three corner reflectors and infrared flares give Teal radar reflectivity and infrared radiation equivalent to that of a fighter aircraft. The drone also employs a visual-tracking system of flares intermittently ejected during powered flight. In addition, it has a compact miss-distance indicator that fires a large flare when a missile comes within a predetermined distance. Teal readily adapts to more complex MD 1 systems for the evaluation of new missile systems.

A trapeze-type pneumatically actuated launcher, which adapts to standard Navy air-to-air missile pylons, tosses the drone clear of the launching aircraft. Switches already installed in the Navy aircraft sequence launching.

Teal Specifications
Sea Level to 55,000 Feet

Wing span	58.8 in.
Overall length	141.5 in.
Max. fuselage diam	10 in.
Flight weight	350 lb
Horizontal-surface span	29 in.
Wing area	6 sq ft
Aspect ratio	4
Max. speed at 50,000 ft (Mach No.)	0.95
Powered flight	8 min



The 8-min duration, dual-thrust engine developed by Astrodyne for the Teal drone.

Rundown on the Teal Motor

Dual-thrust, eight-minute duration solid rocket engine powers XKDT-1, first target drone developed for launching from swept-wing aircraft

By James A. Crask

ASTRODYNE, INC., MCGREGOR, TEX.

James A. Crask is supervisor of Astrodyne's missiles and drones unit and project engineer for the Teal engine. Possessor of a B.S. in chemical engineering from the University of Kansas, he joined Phillips Petroleum Co.'s Research and Development Dept. in 1946, and transferred to Astrodyne when that company was formed early this year. A member of ARS and the Institute of Chemical Engineers, his background includes varied experience in pilot-plant operations, solid-propellant processing and testing, and petroleum research.

SOME TIME AGO, the U. S. Navy awarded Temco Aircraft Corp. a contract for developing what is now the XKDT-1 drone, known popularly as Teal, and described on page 31.

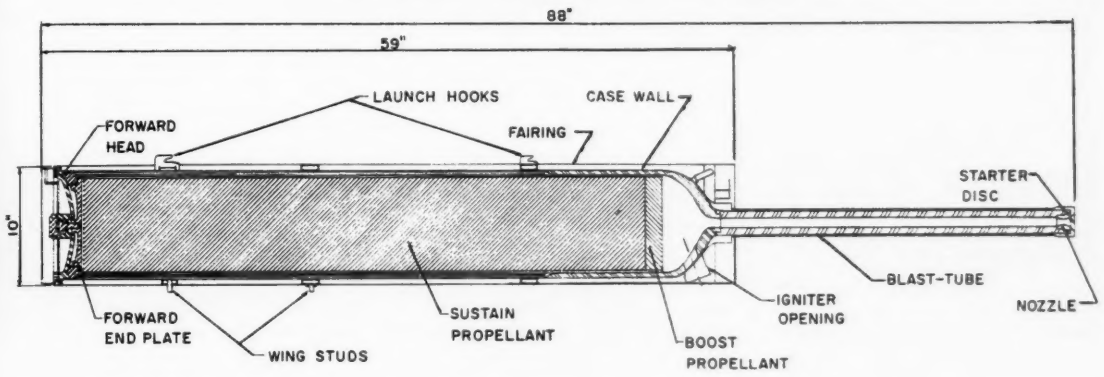
The motor for Teal required dual thrust—a short boost phase to aid launching and drive the drone to cruising altitude, and a long sustainer phase. It also required high impulse-to-weight ratio, a blast tube to conduct exhaust gases through the drone tail, and low external motor-case temperature to protect electrical wiring and instruments outside the motor. In addition, it had to be simple, reliable and economical.

The solid-propellant motor shown on this page was developed by Astrodyne to meet these requirements. The motor, which burns for 8 minutes, employs two grains extruded from medium-energy ammonium nitrate composites. It propels Teal at speeds up to transonic and at altitudes up to 50,000 ft.

The Teal motor shows both conventional and novel design techniques. Two major problems common to solid-propellant motors—grain inhibiting (restriction of the burning surface) and motor-case insulation—were encountered in the development. Unique inhibiting and insulating systems were devised to solve these problems. These systems can be applied to other long-burning, solid-propellant motors.

The case, or pressure vessel, offers a convenient starting place for describing the motor. The motor proper, defined by the geometry

LONGITUDINAL SECTION OF TEAL ENGINE



of the case, rides in a non-structural aerodynamic fairing, which walls in some 17 electrical control wires and three reinforcing rings for distributing loads from launching hooks to the case. These rings, welded intermittently to the case, also increase its strength. The entire pressure-vessel assembly is heat-treated to 190,000-psi yield strength.

Loads Imposed Are Sizable

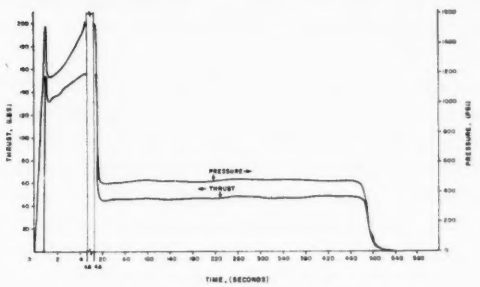
The rings hold three launching hooks on top of the case and three wing-attachment studs on the bottom. The rings also bear sway-brace loads from the launcher. Loads imposed on the pressure vessel during launching and parachute suspension in captive flight are sizable, necessitating the rather complicated reinforcing-ring design.

The fairing, of 0.032-in. thick aluminum sheet, attaches to fore and aft flanges on the case by screws. Launching hooks and wing studs protrude through holes in the fairing, which also has a quick-opening door to permit igniter installation after drone checkout and assembly.

The case shell is rolled and welded 0.090-in. thick 4130 steel sheet; the aft, hemispherical head is hydroformed 4130 steel. The aft fairing-attachment flange joins this head by means of four brackets and a perforated bulkhead. Threaded bosses for blast tube and igniter are welded to the aft head while the head assembly is in turn welded to the shell. Forward closure ring, flange and head are also 4130 steel. A snap ring serves as a locking device, an O-ring as the pressure seal.

A 0.07-in. mild-steel blast tube approximately 29 in. long screws into the aft head. This tube conducts exhaust gases through the tail assembly of the drone. The blast tube (CONTINUED ON PAGE 77)

TYPICAL THRUST-TIME AND PRESSURE-TIME CURVES (60 F)



Internal Ballistic Parameters—Teal Engine (60 F Firings)

Boost chamber pressure	1443	psi
Boost thrust at sea level	146	lb
(Boost thrust at 50,000 ft)	(151)	lb
Boost duration	3.8	sec
Sustain chamber pressure	481	psi
Sustain thrust at sea level	46	lb
(Sustain thrust at 50,000 ft)	(51)	lb
Sustain duration	500	sec
Total impulse at sea level	23,555	lb-sec
(Total impulse at 50,000 ft)	(26,075)	lb-sec
Overall specific impulse at sea level	98	sec
(Overall specific impulse at 50,000 ft)	(108)	sec

Drone radar and IR simulation

Here's a rundown on the techniques employed to provide small target drones with the radiation power of the large aircraft they represent

By A. Winfield McMurtrey Jr.

TEMCO AIRCRAFT CORP., DALLAS, TEX.

A. Winfield McMurtrey Jr., now a research specialist with Temco, has worked on analytic and experimental studies of radar and infrared simulation techniques for drones like the Teal, electronic countermeasures for and against the Corvus missile, and traveling-wave tube amplifiers for radar-echo augmentation. Dr. McMurtrey received his Ph.D. in electrical engineering from Oklahoma State University in 1953. He saw service as a Navy radar officer both in World War II and during the Korean War, and, prior to joining Temco in 1955, was a research engineer for Carter Oil Co., assistant professor at the University of Arkansas, and senior aerophysics engineer on the B-58 electronic countermeasures project at Convair-Ft. Worth.

THE DRONES which are now coming into service or under development must often simulate large aircraft. Being relatively small, these drones will not by themselves reflect radar or emit infrared with nearly the power of the targets they are intended to represent. Consequently, they must be provided with a means of simulating these larger vehicles.

Described here are a few of the practical methods now available for simulating radar and infrared in drones.

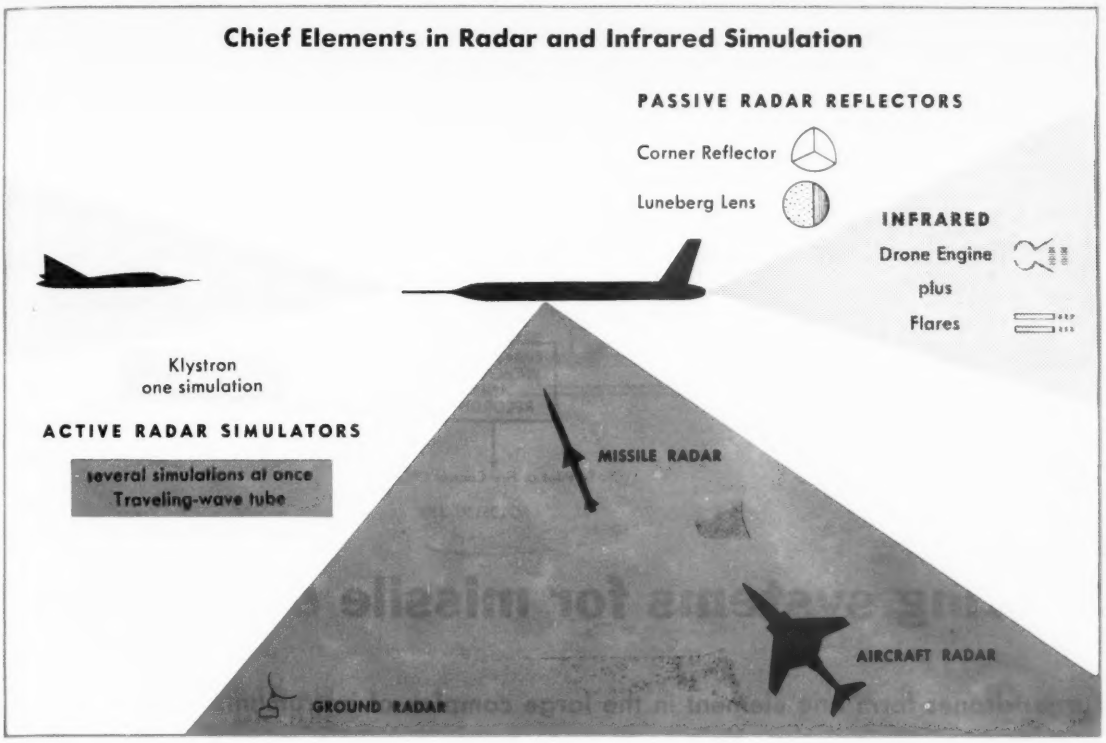
Passive Radar Reflectors

There are principally two kinds of radar reflectors: Corner and Luneberg Lens reflectors. A corner reflector has three mutually perpendicular planes of metal that intersect to form the "corner." Plane sides may be circular quadrants, square or triangular sheets, or some more irregular shape. The Luneberg Lens reflector is a sphere of variable-dielectric materials backed with a metal hemisphere to serve as a reflector.

Both corner and the Luneberg Lens reflectors can be explained most simply as optical reflectors. A ray of light entering the corner reflector may be reflected in sequence by each of the three sides and then re-emerge in the direction of entry. A ray of light entering the Luneberg Lens refracts throughout a path to the metal hemisphere. Then, reflecting from the hemisphere, it follows an exit path symmetrical to the entry path.

Corner and Luneberg Lens reflectors both function well in radar applications if the radar wave length is smaller than the dimensions of the reflector and the radar transmitter and receiver are together in space. If the radar transmitter and receiver are separated physically by an angle with respect to the reflector, either reflector rapidly diminishes in effectiveness as the angle of separation increases.

For this reason, passive radar reflectors are usually insufficient for use on a drone serving as the target for a fast interceptor firing even faster air-to-air missiles guided by radar. Here, the radar transmitter is in the interceptor, the radar receiver is in the missile, and the angle of separation between transmitter and receiver can be



quite large. Also, passive radar reflectors easily become too large physically for a small, fast drone that is supposed to simulate a large, fast aircraft.

Electronic Radar Reflection

Passive radar reflectors simply reflect incident radar waves, and cannot increase the energy or power of the waves. When a passive radar reflector cannot reflect enough energy or power to simulate a large radar target, some means is looked for to add them. An electromagnetic-wave amplifier in the target drone can serve this purpose. It can be shown from the radar range equation that an electronic amplifier, connected to its own receiving and transmitting antennas, can simulate a radar target that varies in size directly with the amplifier and receiver-and-transmitter antenna gains and which also varies directly as the square of the wave length of the incident radar wave.

This relation is of immense practical value. It means that simple pre-flight gain control to an amplifier in a drone can make the drone appear to a radar as a much larger aircraft of specified size. Receiving and transmitting antennas for the amplifier can shape the spatial pattern of the simulated radar reflection such that, viewed from many aspects, the target drone appears to the radar as a much larger aircraft.

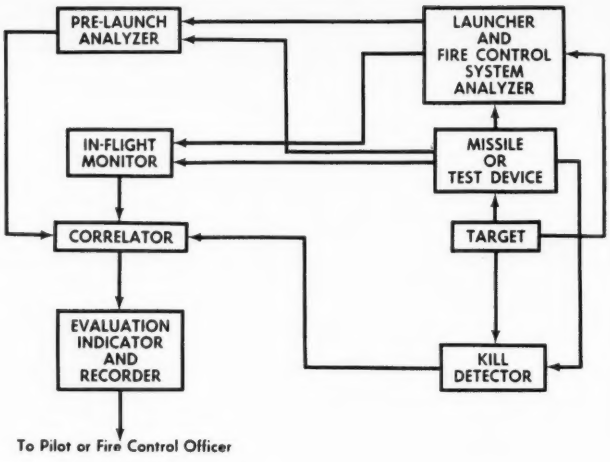
An amplifier in a drone, then, can rectify the two serious disadvantages of passive radar reflectors. The amplifier can simulate radar reflection many times greater than that from a reflector in any particular direction; and, by proper choice of the amplifier and its receiving and transmitting antennas, the simulated reflection can be made large over wide spatial aspects, so that the target drone continues to simulate a large aircraft even when used with a separate radar transmitter and receiver, as mentioned previously in connection with an interceptor firing semi-active, radar-guided missile.

All that remains is the choice of amplifier. For the higher radar frequencies, which are invariably associated with interceptors because of the smaller bulk of the airborne radar, vitually the only microwave electronic amplifier tubes applicable are the klystron and the traveling-wave tube.

Can Be Electronically Tuned

The klystron, subject of tremendous developmental effort for radar during World War II, has a narrow inherent frequency bandwidth, but it can be electronically tuned over a frequency range of 30 to 60 mc and mechanically tuned over a wide frequency range, such as 8500 to 9600 mc. In other words, mechanical tuning of the klystron is a rough adjustment and electronic (CONTINUED ON PAGE 80)

STATE OF THE ART INTEGRATING SCORING SYSTEM . . .



Scoring systems for missile evaluation

Target drones form one element in the large complex of instruments required to evaluate weapon systems in simulated combat conditions

By C. R. Bonnell and D. E. Lloyd

BEECH AIRCRAFT CORP., WICHITA, KAN.

Bonnell Lloyd

C. R. Bonnell, chief of weapon system electronics at Beech, has had 14 years of missile and related electronic experience. Prior to joining Beech, he was chief engineer for Cedar Engineering Co.; research project engineer with Aero Div., Minneapolis Honeywell; and instructor of mathematics at the University of Missouri, where he received an M.S. in physics. At Beech, he has system responsibility for electronic systems and components, including design, analysis and proposals.

D. E. Lloyd, Beech design engineer, is responsible for the design and placement of radar reflectors and radomes in target drones; testing and evaluation of foam plastics for radar transparency; design studies of radar lenses and traveling-wave tubes as amplified in radar transponders; and design studies of scoring systems. A graduate of the University of Kansas with a B.S. in electrical engineering, he was formerly a flight and ground school instructor for the Navy.

AN INTEGRATED scoring system is a method for examination, diagnosis and treatment of a weapon system during development and training phases. The weapon system can be automatically monitored and analyzed to determine its faults and limitations by correlating pre-launch and in-flight data with scoring evaluation. The complete operational mission can then be evaluated with respect to equipment or human performances.

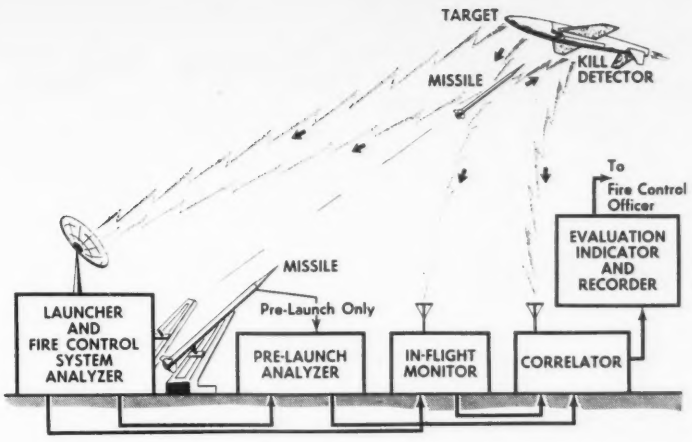
The block diagram on this page shows an integrated scoring system within the bounds of the present state of the art (kill detector excepted).

The launcher and fire control system analyzer receives data from the fire-control system, launcher, missile, target and checkout equipment for pre-launch analysis. These data are analyzed from an airborne or surface fire control and launching system or, dependent upon the missile system, from combinations of the two.

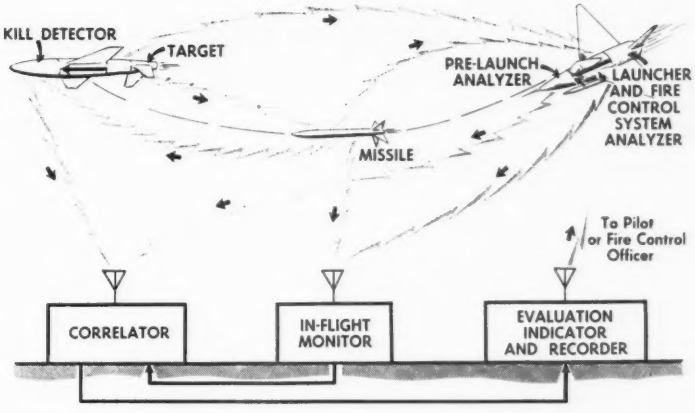
The pre-launch analyzer sends the data to a correlator, where they are grouped with in-flight monitor data and with information from the kill detector. To save space, in-flight monitor data may be omitted from the system during operational training phases when missiles are used fuzed and armed.

The target may check the performance of the fire-control system and the missile by means of evasive maneuvers, countermeasures, etc. These facts are recorded and correlated through the fire-control system and the missile.

. . . **FOR SURFACE-TO-AIR MISSILES**



. . . **AND AIR-TO-AIR MISSILES**

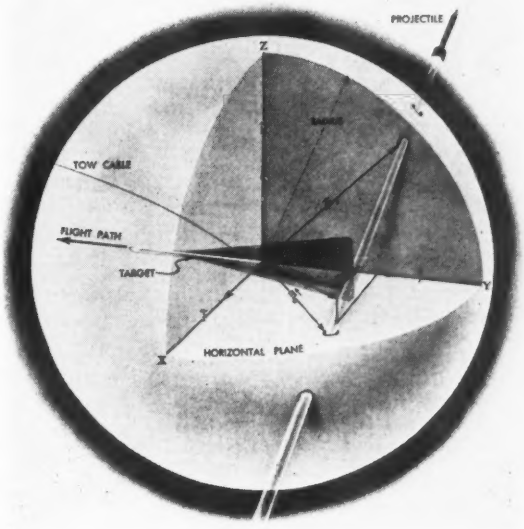


The kill detector measures the effectiveness of the weapon system by providing position data from the missile and target for correlation with pre-launch and in-flight data. The correlator thus provides information for complete flight evaluation of the system at the evaluation indicator and recorder. The evaluation indicator and recorder makes a permanent integrated record of a mission and the reason for its success or failure. It also gives an indication of this to the fire-control officer or pilot.

If the weapon system to be tested involves a surface-to-air missile, the launcher and fire control system analyzer, along with the pre-launch analyzer, in-flight monitor, correlator, and evaluation indicator and recorder will be located on the ground, at either the missile launching site or some intermediate control station on the firing range, as shown in the first diagram on this page.

When the integrated concept is applied to air-to-air missile systems, as shown in the second drawing, the launcher and fire control system analyzer is carried on an unsteady platform subject, in some instances, to airframe characteristics and pilot proficiency. The pre-launch (CONTINUED ON PAGE 76)

SCORING DEFINITION CRITERIA



At left, the OQ-19B target drone used in Army surveillance system tests in 1956, and (right) the SD-1 surveillance drone which grew out of the tests.

Combat surveillance and the drone

Test of drones in Army's interim Combat Surveillance System in 1956 proved their usefulness and set goals for present and future developments

By Capt. Kirby Lamar (USA)

U.S. ARMY ELECTRONIC PROVING GROUND, FORT HUACHUCA, ARIZ.

Captain Kirby Lamar, a graduate of the U.S. Military Academy, has seen duty with the 82nd Airborne Division and later with the 25th Infantry Division in Korea. Upon returning from Korea, he was assigned for study to the University of Michigan, where he took an M.S. in electronic engineering. He has been a member of the Combat Surveillance Department at the U.S. Army Electronic Proving Ground at Fort Huachuca, Ariz., since 1955, and in this capacity has had ample opportunity to observe the development of drones for combat surveillance missions.

COMBAT SURVEILLANCE has been defined as the "continuous, all-weather day-and-night systematic watch over the battle area to provide timely information for tactical ground-combat operations . . ." The Army began a formal combat-surveillance program in 1953 to provide advanced surveillance equipment and the organizational and doctrinal concepts for employing it.

Three years of evaluating and modifying available commercial and military equipment in the light of new studies of tactical needs led to test exercises with an interim Combat Surveillance System in Sept. 1956. Tested were photographic, infrared, television and radar detection devices, in conjunction with equipment for transmitting, processing and displaying data. Modified target drones provided platforms for aerial photography in the exercises.

Some examples of the equipment tested will serve to describe the Combat Surveillance System in experimental form. Many sources of surveillance information necessary for a true simulation of combat tactics, but not associated with work at the Army Electronic Proving Ground, were plugged into the system in the form of canned messages. These will not be touched on.

Passive infrared devices were used for both ground-to-ground and air-to-ground surveillance. These devices gave various presentations, from a strip map to an indicator reading which told only that a hot object was within a defined field of view. Infrared devices were operated only at night.

An experimental airborne television sub-system was also tested. The components were mostly commercial items assembled solely to test a technique. In order to evaluate the advantages of ground

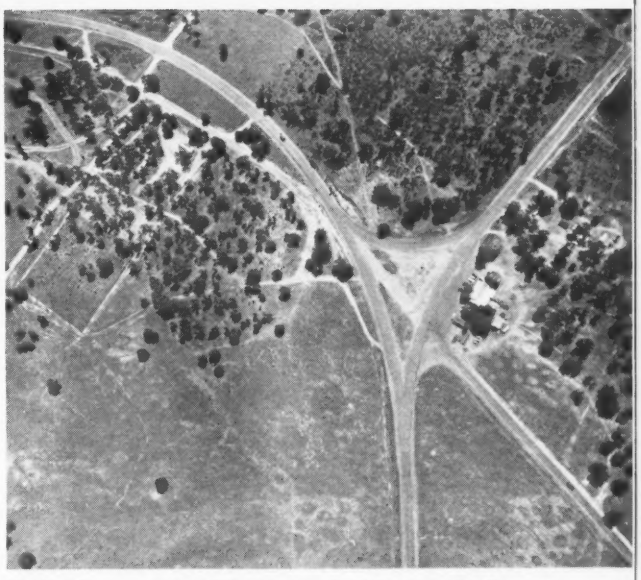
control for airborne television, an L-19 aircraft was modified for remote control, with a pilot accompanying the aircraft in the interests of safety. A ground-radar tracking and plotting system served as the navigation link and also as a means for accurately locating objects of interest displayed on the ground television monitor.

Ground Doppler-radar detected moving personnel or vehicles. In general, the maximum range of the set employed at an echelon was commensurate with the maximum range of the weapons normally assigned to that echelon. A brief discussion of one type of ground-radar set—the AN/PPS-4, or Silent Sentry—will illustrate the surveillance application. This radar, which has a beamwidth of 6.5 deg, can detect vehicles at 5000 yd and personnel at 1000 yd. Weighing 85 lb, it can be carried by ground troops. It obtains its primary power from a gasoline engine-generator, operates in the X-band frequency range and announces a detected object in an audio manner. Range and azimuth indicators give precise locations of detected objects.

Detectors were widely distributed throughout the simulated battle area. Data-transmission channels were therefore needed to deliver information to the various intelligence sections for processing. Normal wire and radio circuits fulfilled the requirements for voice, teletype and facsimile communications. A manual method, the McBee Keysort Card System, served to file the numerous intelligence reports efficiently. Data were also manually transferred to maps for display purposes.

Manifold Benefits from Tests

The benefits derived from the test were manifold. Some equipment was recommended for immediate adoption by the Army, and some recommended for adoption subject to specified modifications. Research and development objectives were outlined along with future concepts governing the organization and doctrine of tactical surveillance systems.



Little drone gives "big picture"—photograph from OQ-19B drone taken at an altitude of 750 ft in 1956 test.

Since the completion of the 1956 test, capabilities of surveillance equipment have been materially enhanced. New equipment has been introduced for testing, and many of the original items have been made smaller, more reliable, easier to operate and maintain, less power consuming and better in operating performance.

Advances of much greater significance will come about in the near future. Airborne radar detection devices, capable of large area search and timely transmission of information to ground receiving stations, show great potential already. The more distant future should bring integrated airborne devices consisting of combinations of radar, infrared, television and photographic sensors.

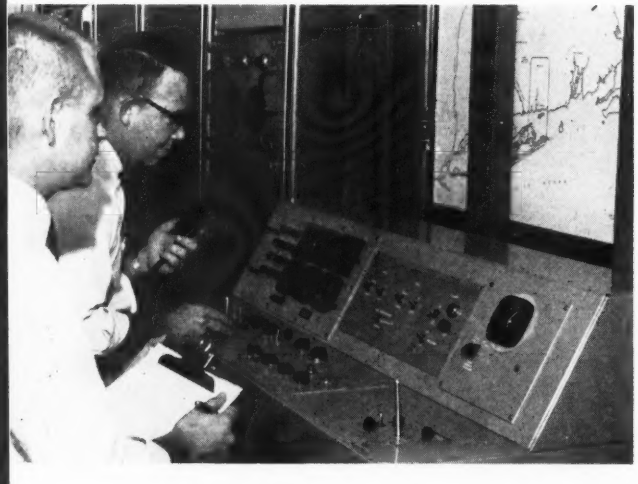
Now let's turn to the surveillance drone itself. It was realized early in the (CONTINUED ON PAGE 84)

Present mobile ground-radar station used by Army with surveillance drones.

New drone-guidance system

Developed by Sperry for ARDC, it enables a control van or aircraft to track and control a drone, and receive feedback signals from it

How Sperry drone-guidance system works. In drawing above, drone (1) simulates enemy missile. Coded command signals from van (2) pass to aircraft link (3), which can relay signals or direct drone itself. In photo below, engineer with mike "flies" drone while his companion monitors the mission. Board at right automatically plots drone's route.



SPERRY GYROSCOPE CO., under a contract from ARDC, recently demonstrated successfully a microwave command-guidance system for subsonic and supersonic target and reconnaissance drones and unmanned aircraft. This system enables a master control van or a far-ranging aircraft link to track a drone, command its engine and flight controls, and receive drone feedback signals. Tracking, command and feedback functions all ride a single radar-frequency band.

Designed for Universal Drone Use

ARDC states that the Sperry system is the first specifically designed for universal drone use. The system can control drones simulating missiles for air-defense training and research and development work; unmanned conventional aircraft of all types needed in full-scale tests of air defenses; and drones for reconnaissance.

The system is the first to satisfy stringent test requirements for present air defense missile systems and the first able to control remote low-altitude aircraft at great distance. The first scheduled use of the system will be to direct such developmental supersonic drones as the Q-4 and Q-5 (see page 23) in simulated attacks to test the effectiveness of air-defense missiles.

The accompanying illustrations show the interior of the control van and a typical employment of the system to test air defense missiles. The control van, which can be transported by aircraft, contains all the equipment necessary to direct a mission.

The drone carries highly transistorized transmitting and receiving equipment. The van and drone exchange coded signals directly in relatively short- or high-altitude missions. Signals relay through the aircraft link in long-range or low-altitude missions. The aircraft link carries radar, receiving, tracking, command and plotting equipment similar to that in the control van, and consequently can also control the drone alone.

Steps into space

Hugh L. Dryden
Director, NACA

Proposed NASA program, revealed in Dryden testimony before House Committee, calls for intensive research effort, development of telescope-carrying satellites, larger engines, and manned and unmanned vehicles

IN A STATEMENT presented to the House Select Committee on Astronautics and Space Exploration in mid-April, Hugh L. Dryden, director of the National Advisory Committee for Aeronautics, expanded on the President's recommendation for the establishment of a new National Aeronautics and Space Agency (NASA) using NACA as a nucleus, and outlined some of the space projects proposed by NACA for NASA accomplishment.

Dr. Dryden envisioned a broad three-part program, combining an adequate research effort on space technology problems with development and use of unmanned vehicles capable of carrying necessary scientific data-gathering apparatus and development and orderly use of manned vehicles capable of exploring the solar system. He noted that such programs would not be planned or accomplished in sequence, since manned trips to Mars or Venus would certainly come later than some of the other work. Rather, he anticipated a comprehensive program, with progress made in all three areas as rapidly as new knowledge is acquired.

"Snooper" Satellite Seen Needed

In the way of specific projects, the NACA director assigned high priority to development of a satellite capable of carrying an astronomical telescope and TV equipment necessary to send pictures taken through the scope back to earth. He noted that it would be possible to build a telescope of the necessary size, together with supporting equipment, to be carried in a satellite weighing about a ton. Stabilization of the satellite itself would be difficult, he added, but could be accomplished.

Other top priority NASA projects would be development of rocket engines more powerful than those required by present ICBM's—specifically, engines with 1 million lb of thrust—and design studies of various types of manned vehicles, carried out in NACA facilities.

The transformation from NACA to NASA will entail considerable reorientation of present NACA research programs, Dr. Dryden noted. To effect this change, he informed the House Select Committee:

"We are making plans with regard to our internal organization and management structure to assure that expanded operations, especially in the areas of space vehicle development and use, be promptly and efficiently undertaken. Although these plans have not been finalized, they will include new elements as well as the effective operating mechanisms evolved by NACA over the past 43 years.

New Facilities Under Study

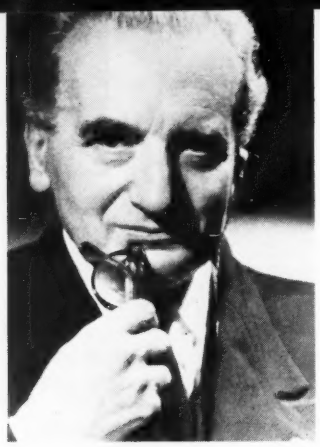
"We are also planning additional actions and programs that will be necessary to assure rapid implementation of the proposed legislation. This includes determination of the requirements for additional staff, facilities and funds that will be needed."

The Budget Bureau's preliminary minimal estimate of NASA expenditures, he noted, ranging over and beyond the $100 million budget of NACA, is from $100 million in fiscal 1959 to $300 million in fiscal 1962.

"We have undertaken with Defense Dept. officials," he continued, "the review of pertinent space programs currently under way or planned by the department, including lunar probes.

"We will discuss with the National Science Foundation and the National Academy of Sciences, as well as with other governmental and nongovernmental bodies, participation by the scientific community on a continuing basis in the planning and coordination of scientific programs for the use of space vehicles.

"The future relationship between AEC and NASA can be expected to be even more intimate as the idea of exploiting the great potential of nuclear energy becomes more (CONTINUED ON PAGE 84)



Von Kármániana

Theodore von Kármán is almost as well known for his wit as for his many scientific contributions . . . Herewith, a treasury of von Kármán witticisms

By Lee Edson and A. K. Oppenheim

GENIUS — AND WIT

Everyone fortunate enough to be acquainted with Theodore von Kármán knows how fond he is of an amusing story. Indeed, among his devoted colleagues and followers, his wit is almost as famous as his scientific contributions. Many a dull meeting has been brightened by a von Kármánian witticism and many a difficult scientific concept clarified by a humorous von Kármánian remark. More than any other single characteristic, this humorous side of the man reflects the warmth and humanity of his colorful personality.

Until now, however, von Kármán stories have been kept alive only by word of mouth. The authors feel it is high time these stories were preserved in written form, so that they may be shared by all. This article represents the first attempt to assemble a treasury of von Kármániana.

The authors are willing to take on the burden of collecting additional witticisms, humorous reminiscences or anecdotes told by or about the good doctor. They would welcome contributions, and ask only that the stories bear a mark of authenticity, including, if possible, the time and place the story was told—and, of course, that they be printable.

Lee Edson, well-known magazine writer and author, became acquainted with Dr. von Kármán while doing an article about him for the Saturday Evening Post. Antoni K. Oppenheim, associate professor of mechanical engineering at the University of California at Berkeley, is a long-time von Kármán admirer.

ANY COLLECTION of von Kármániana should begin with a selection taken from the master's own words. A few samples:

"Many great men who have the imagination to work out systems of ideas for themselves share the weakness of forgetting where an early inspiration came from. For example, it seems that Sir Joseph John Thomson (1856–1940), the great English physicist, was somewhat that way. His pupil and friend, Sir Francis W. Aston, once told me that it was quite amusing to tell something new to Thomson. If you told him an idea on Wednesday, he shook his head; on Thursday, again he would not believe it; but on the next Monday, he would come to you saying, "Now, look here, the thing is so . . ." Thereupon he would propound the same idea you had told him before, ending with, "Now, do you understand the problem?" (Theodore von Kármán, AERODYNAMICS, Cornell University Press, 1954, p. 51.)

Expert on Family Relationships

Von Kármán is not only well informed on the scientific opinions of his colleagues, but often surprises people by his amazing insight into their family relations. On page 51 of Aerodynamics, he says: "But his (Prandtl's) ability to establish systems of simplified equations which expressed the essential physical relations and dropped the nonessentials was unique, I believe, even when compared with his great predecessors in the field of mechanics—men like Leonhard Euler (1707–1783) and D'Alembert (1854–1924) in Munich. Föppl himself did pioneering work in bringing together applied and theoretical mechanics. Later, Prandtl became Föppl's son-in-law, following the good German academic tradition. There is a saying—I do not know its author—that it is remarkable how often scientific talent in Germany has descended from father-in-law to son-in-law, instead of from father to son."

Selections from the von Kármán "Devil's Dictionary"

On Experts: *"An expert is any engineer who lives 300 miles away from the home office."*

On Security: *"The mistakes of the Military are all classified."*

On Hungarians: *"A Hungarian is a man who goes into a revolving door behind you and comes out ahead of you."*

(Quoted in Time Magazine, May 21, 1956)

On Scientific Reasoning: *"First comes articulation of the problem, then the complexities, then the disagreements, and finally the Slivovitz."*

(Ibid)

On Hydraulics: *"Hydraulics is the science of variable constants."*

(Quoted in Aerodynamics, p. 80)

On Engineers: *"A practical engineer is one who perpetuates the errors of his predecessors.'*

(Attributed to J. M. W. Rankine by von Kármán in Aerodynamics, p. 167)

On Crash Programs: *"Instead of making one girl pregnant for nine months, you get nine girls pregnant in one month."*

(AGARD meeting in Palermo, March 17, 1958)

While describing the phenomenon of wake drag and vortex street, von Kármán writes: "Bénard did a great deal of work on the problem before I did, but he chiefly observed the vortices in every viscous fluid or in colloidal solutions, and considered them more from the point of view of experimental physics than aerodynamics. Nevertheless, he was somewhat jealous because the vortex system was connected with my name, and several times—for example, at the International Congresses for Applied Mechanics held in Zurich (1926) and in Stockholm (1930)—claimed priority for earlier observation of the phenomenon. In reply I once said, 'I agree that what in Berlin and London is called Kármán Street in Paris shall be called Avenue de Henri Bénard.' After this wisecrack, we made peace and became quite good friends." (*Ibid.*, p. 68–69.)

° ° °

"In 1945, a group of American scientists was engaged in collecting German papers and documents produced during the war. The list of German papers was translated into English by an American sergeant. One of my collaborators found, in the list of papers on 'Aerodynamics,' one entitled 'Resistance of Undernourished Bodies.' This was the sergeant's rendering of the German translation of my paper on 'Resistance of Slender Bodies.'" (*Ibid.*, p. 117.)

° ° °

"Every major aircraft company has a department devoted especially to the flutter problem. Some years ago, when 450 to 500 mph was still a high speed, the president of an aircraft company in California got a call from Wright Field informing him that his prototype airplane had encountered flutter at 450 mph.

"The president called in his vice-president in charge of engineering and said, 'This is a scandal. We have the best mathematicians, a whole department for flutter, and still General X calls me from Wright Field to say we have flutter at 450 mph.'

"So the vice-president went to the head of the flutter group and said, (CONTINUED ON PAGE 72)

missile market

Financial news of the rocket and guided missile industry

BY ROBERT H. KENMORE

FOR the third consecutive month, neither the general market nor the missile industry segment went anywhere during April.

This column has always advocated the long-range view, as opposed to investments which attempt to capitalize on the hazardous predictions of short-term market activity, it is fitting that we discuss current developments which may drastically change the future investment picture in the missile industry. The first of these might be called: "Where is the money going to come from?"

Up through the end of the Korean War the demands made on the country's economy by Defense spending, although very large, were never really out of proportion to our average productive capacity. Even today, we have very quickly gotten used to incorporating into our economic thinking such things as a $2 million Atlas, a Polaris-launching submarine fleet costing $3 billion, and a ballistic missile program which in the eight years through 1959 will have cost us over $6 billion.

However, signs of strain are now beginning to show. We are entering into the Space Age, when a *single* vehicle may cost $1 billion to develop and an operational capability may exceed $1 trillion. Even then the task of paying for the necessary scientific developments that will bring us into this new era of man's travels would not be quite so formidable were it not that we must continually cope with each and every development of the Russians.

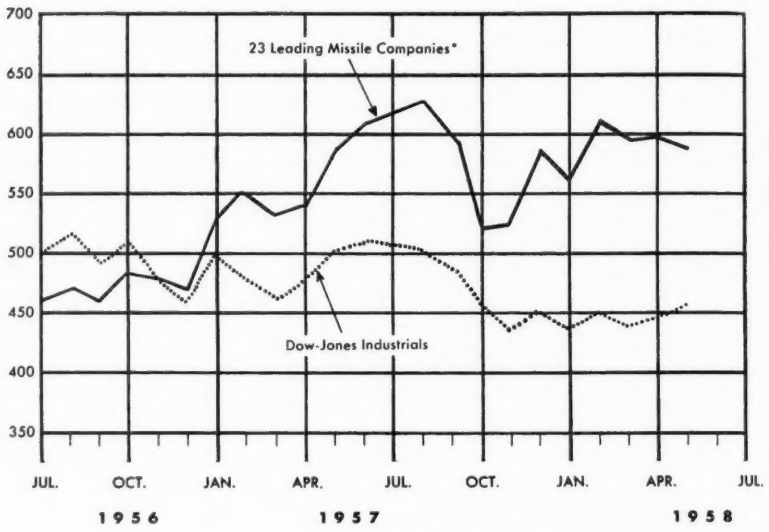
We are under double pressure of always "being ready" (if the Russians are thought to have a single, new operational weapon we must immediately produce a hundred similar items on the assumption that if the Russians have one they could just as well have another ninety-nine, and if we had any less the nation's security would be imperiled) and of trying to catch up and to even exceed Russia's rapid rate of new advances. As this race takes us further and further away from the earth's atmosphere, the cost of success mounts in such gigantic proportions that present dollar expenditures will look microscopic.

Where, then, is this money going to come from? First of all, it is obviously imperative that the whole method of spending by the Government be studied thoroughly and revamped drastically so that all waste is eliminated from the development program that confronts us. As to raising additional funds that will be required, all answers are frightening. Eliminating the unthinkable possibility that we become a military state, the only alternatives seem to be increasingly larger deficit budgets which will lead us to national bankruptcy or progressively higher taxes which will bring us to personal starvation. The Nation is unfortunately still too close to the post-war boom to be attracted to longer-range alarmist predictions.

High purchasing power for all and complacency go hand-in-hand. Investment are a part of a man's lifetime planning and must be attuned not only to the past, the present and the immediate future but also to what lies ahead for his generation. . .and his children's generation. The investor is called upon to supply the capital for our country's growing enterprises and he will only continue to supply this capital if he can be assured that the growth is sound and that the return on his investment is adequate. He is therefore the one with the biggest stake in the future economic development of our nation and he must make sure at all times that this stake is protected.

The second development, which must of necessity follow on the first one, is the changing philosophy in the Pentagon with regard to the awarding of contracts. All types of new concepts are being voiced and most of them seem to lead to two possible related conclusions of tremendous importance to investors. The first of these is that contracts may one day be awarded to a completely different group of companies than the ones that are the major beneficiaries of these awards today. The other point is that the whole profitability structure on present Government work may change completely with certain contracts yielding no profit at all while others may afford much greater profits than are currently being allowed. Both of these factors, which are still only being talked about but which could materialize in fact through the pressures of the economic problems already discussed, would create even greater difficulties than now exist today in selecting the securities of those companies which will profit the most from our entry into the Space Age.

THE MARKET AT A GLANCE



*Index compiled June, 1955

	May 1958	April 1958	% Change	May 1957	% Change
Dow-Jones Industrials	455	449	+1.3	498	−9.8
Missile Index	589	596	−1.2	595	+0.2

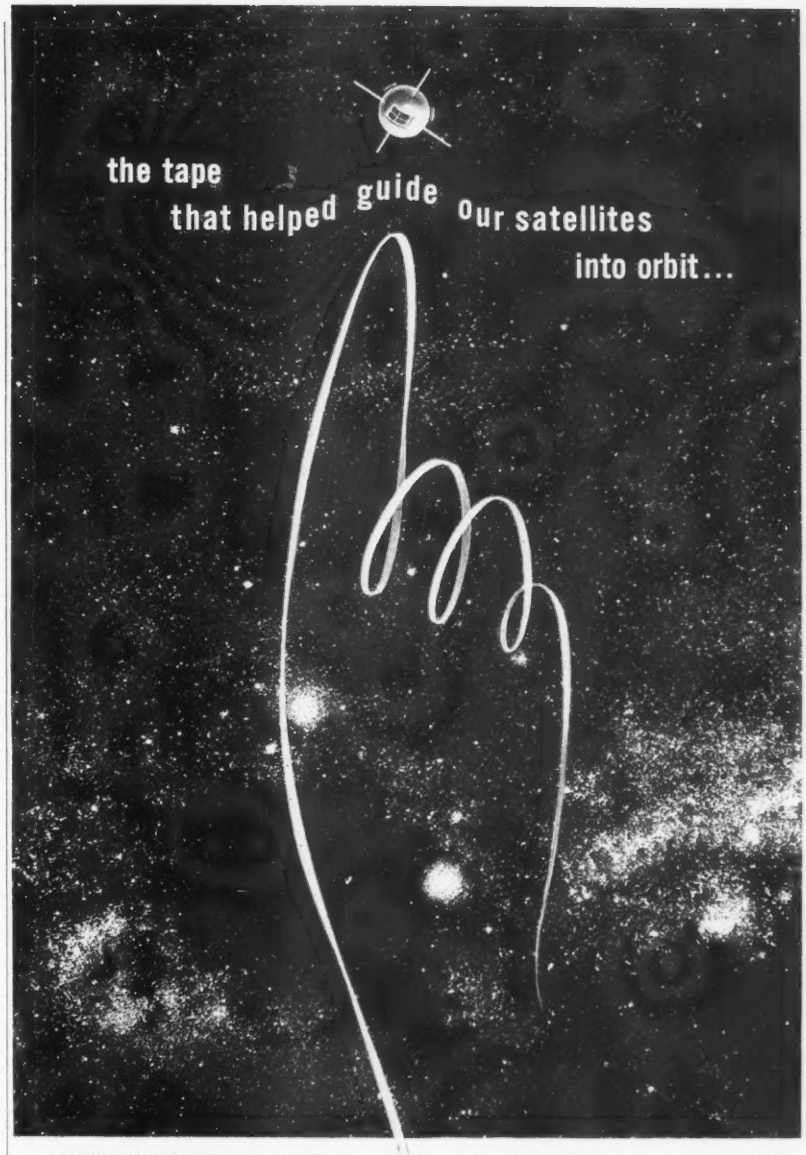
On the question of awards, many are already bypassing the major primaries and going to the smaller firms who have a higher degree of technological knowledge in the area which is most applicable to the particular device being developed. The syndicate method of awarding a contract to a group of companies at the same time, instead of letting the prime contractor choose his own subs, is also gaining more adherents. In a recent speech the Under Secretary of the Air Force said: "Today's secondary courses, such as electronics and propulsion equipment, will be the prime contractors of the future."

All these factors seem to indicate that the "missile industry" as we know it today is subject to many upheavals and it is conceivable that our Missile Index, five years from now, will be made up of a completely different group of companies than the ones it now encompasses. On the second point—that of profitability—the Government is concerned over the lack of incentive in the current method of doing business, as well as the lack of any means of enforcing performance on contracts. By changing over to a more flexible method of gearing profit to performance, it it felt that available monies will be expended more efficiently.

This again must lead the investor to an inquiry into which companies will be affected by such a change. By placing a higher premium on management efficiency at the expense of mere size or historical connections many companies that are now on the scene could be replaced by others who can perform better under the new circumstances.

It is not the intention of this month's column to suggest that the investor should renounce the idea of ever hoping to put his money to work profitably by purchasing equity securities. It is however the duty of this column to interpret economic developments insofar as they may affect these purchases and to urge the exercise of caution and full investigation before such purchases are made.

If the above comments seem unduly pessimistic, they must be put in the frame of reference that although the writer does not offer the answers to the problems we face, he does not for one moment doubt that these answers will be found. Also, bullish opinions expressed in previous columns as to the opportunities available for profitable long-term investments in the missile industry have in no ways changed. On the other hand, our admonitions on the need for careful research to find these opportunities are also still valid and will, we hope, be reinforced by our current comments.



SOUNDCRAFT TYPE A TAPE FOR DIGITAL RECORDING

The Ford Instrument guidance system in Army Jupiter-C missiles that launched the Explorers into space...and the recording system in the Navy's Vanguard...employed a most reliable magnetic medium — Soundcraft Type A Tape. Only Soundcraft Type A Tape has electrical and physical stability to merit selection in these vital missions ...and in your own instrumentation applications. The RCCH oxide formulation in Type A Tape provides higher signal output and greater retentivity... plus unique surface hardness and high thermal stability. Soundcraft's exclusive Micro-polishing and Uni-level coating processes help provide the electrical and physical uniformity found only in Soundcraft Type A Tape. Send for detailed Type A Brochure!

One tape can't serve all needs...For Your Telemetering Applications... write for brochure on Soundcraft Type B Tape for Telemetering!

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ARS news

Another Los Angeles Meeting for ARS–After Three Years

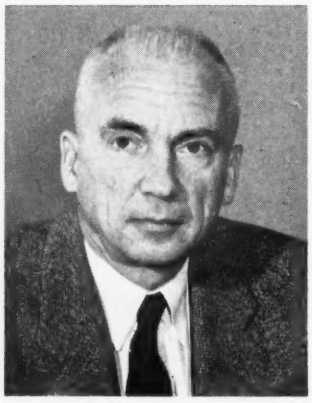
Three years is a long time. The last time the Southern California Section was host to a national AMERICAN ROCKET SOCIETY meeting was in September, 1955. At that time, great satisfaction was felt because attendance at the meeting topped the 500 mark–quite an accomplishment for a Society which was still young, in an industry which was still an adolescent.

In the intervening three years, the industry has burgeoned, the Society's membership has grown to 10,000 and the Southern California Section, along with spawning the San Diego, Antelope Valley and Central California Sections as separate entities, has increased its own membership from 645 to more than 2000.

It is little wonder, then, that the attendance of more than 1500 expected at the upcoming ARS Semi-Annual Meeting at the Hotel Statler in Los Angeles June 9–12 will result in few raised eyebrows.

Even more impressive than the growth of the Society in the 33 months since the last Los Angeles meeting, however, is the impressive list of technical developments and new ideas spawned in the fields of jet propulsion, rocketry and astronautics during this period.

The 13-session program for the meeting, arranged by National Program Chairman Howard Seifert of Space Technology Laboratories in co-operation with the seven ARS Technical Committees, tells part of the story of these developments.



Norris Bradbury, luncheon speaker

It speaks of achievements in modern weapon systems–Atlas, Titan, Thor, Redstone, Talos, Regulus, Polaris. It examines ideas for instrumenting, testing and managing such programs. It looks ahead to solid, liquid and nuclear rockets of the future, to lunar satellites, to interplanetary flight. It presents the first full-scale report of the most important scientific program of our time–the IGY program, which produced this country's first successful attempts to conquer space, as well as the successes in this direction achieved by another country with its eyes on the stars.

But these technical sessions are by no means all that is offered at the meeting. Certain to be a highlight in these times, when every youngster seems to be interested in rocketry and astronautics, is the first Western Regional Student Conference, arranged by Andrew F. Charwat of UCLA and bringing together four outstanding engineers and scientists for a discussion of "State of the Art in Rockets and Missiles."

Not to be overlooked, also, is the first ARS Astronautical Exposition, to be held at the Statler during the meeting, which will exhibit components, equipment and complete rockets and guided missiles produced by many of the most important companies in the industry.

Many of those attending the meeting will take an extra day to go on one of the field trips offered on Thursday, June 12. They can visit the Consolidated Western Steel Div. plant at Maywood, JPL, Rocketdyne's Canoga Park plant and Santa Susana test area, or Northrop's plant at Hawthorne.

And, of course, the outstanding line-up of speakers who will appear at the three luncheons and banquet–George Metcalf, general manager of GE's Missile and Ordnance Systems Dept.; Norris Bradbury, director of the Los Alamos Scientific Laboratory; Rear Adm. John E. Clark, deputy director of ARPA; and Lee DuBridge, president of the California Institute of Technology–virtually assures the presentation of some stimulating ideas to those attending the meeting.

Equally important is the fact that the entertainment program arranged by the Meeting Committee under Charles A. Knight, General Chairman, and Dan Brewer, President of the Southern California Section, means that ARS members, *and their wives*, are sure to find something of interest.

Yes, three years is a long time–in this business. **—J. H.**

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Szego on ASTRO Staff

George C. Szego, manager, Thermodynamics Engine Section, General Electric Co., Cincinnati 15, Ohio, has joined the staff of ASTRONAUTICS as Consulting Editor. Dr. Szego, a member of the ARS Space Flight Committee, will handle articles for the magazine dealing with space flight, space propulsion, etc., and papers in this area should be addressed to his attention at the above address.

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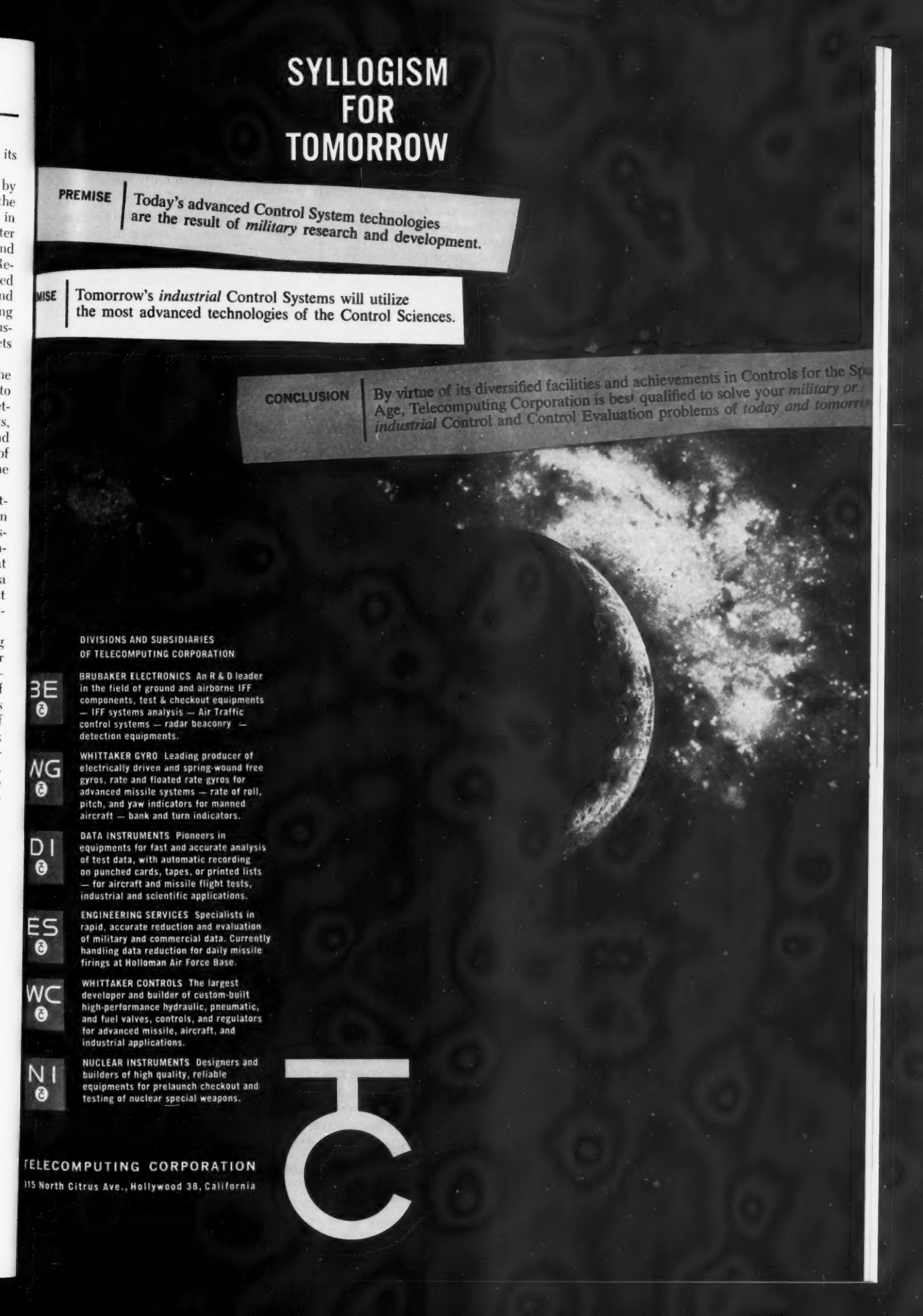

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on the calendar

1958	
June 2–4	**National Telemetering Conference under auspices of ARS, IAS, AIEE, ISA, Lord Baltimore Hotel, Baltimore, Md.**
June 9–12	**ARS Semi-Annual Meeting, Hotel Statler, Los Angeles, Calif.**
June 16–18	Second National Convention on Military Electronics, sponsored by IRE, Sheraton Park Hotel, Washington, D.C.
June 16–20	Annual Meeting of American Society of Engineering Education, University of California, Berkeley.
June 19–21	**Heat Transfer and Fluid Mechanics Institute Meeting, University of California, Berkeley.**
June 23–24	1958 Summer Meeting of Western States Section, The Combustion Institute, University of California, Berkeley.
June 23–July 3	Special Summer Program in Random Vibration, MIT, Cambridge, Mass.
June 25–27	1958 Air Transportation Conference, sponsored by AIEE, Statler Hotel, Buffalo, N.Y.
July 8–11	IAS National Summer Meeting, Ambassador Hotel, Los Angeles, Calif.
Aug. 5–6	**Space Exploration Meeting sponsored by ARS, IAS, San Diego Sections.**
Aug. 13–21	10th Assembly of the International Astronomical Union at Moscow.
Aug. 25–30	**Ninth Annual Congress of International Astronautical Federation, Amsterdam, The Netherlands.**
Sept. 1–6	1958 Farnborough Flying Display and Exhibition, Farnborough, England.
Sept. 3–5	1958 Cryogenic Engineering Conference, MIT, Cambridge, Mass.
Sept. 8–13	First International Congress of Aeronautical Sciences, sponsored by IAS, Madrid, Spain.
Sept. 15–18	**ARS Meeting, Hotel Statler, Detroit, Mich.**
Sept. 22–24	IRE National Symposium on Telemetering, the American Hotel, Bal Harbour, Miami Beach, Fla.
Oct. 13–15	National Electronics Conference, sponsored by IRE, AIEE, EIA, Hotel Sherman, Chicago.
Nov. 10–13	AF School of Aviation Medicine-Southwest Research Institute Space Flight Symposium, San Antonio, Tex.
Nov. 17–21	**ARS 13th Annual Meeting, Hotel Statler, New York, N.Y.**

Ten More Companies Become ARS Members

Ten more companies have become corporate members of the AMERICAN ROCKET SOCIETY. The companies, their areas of activity and those named to represent them in Society activities, are:

• Chandler-Evans Division of Pratt & Whitney Co., Inc., West Hartford, Conn., active in manufacturing, testing and application of rocket powerplants, controls, components, accessories, systems and propellants. Representing the division in ARS are: J. O. Nash, assistant chief engineer; L. G. Burns, sales manager; H. E. Francis, senior staff engineer; E. J. Vitali, assistant chief engineer; and A. M. Wright, chief engineer.

• Avco Research Laboratory, Everett, Mass., active in theoretical and experimental research in high-temperature gas dynamics and hypersonic flight. Representing Avco in ARS are: Arthur Kantrowitz, director; Mac C. Adams, deputy director; Frederick R. Riddell, principal research scientist; Peter H. Rose, principal research engineer; and Frederick C. Durant III, executive assistant to the director and former ARS President.

• **Missile and Ordnance Systems Dept., General Electric Co.,** Philadelphia, Pa., active in design engineering and prototype and production manufacturing of missile weapon systems, including instrumentation, guidance, propulsion, airframes, arming and fuzing, ground support and field test equipment and flight testing. The department also is responsible for design and manufacture of naval fire control systems, radar antennas and systems, and underwater and airborne ordnance equipment.

Named to represent the department in ARS are Hilliard W. Paige, manager, project operations; F. E. Rushlow Jr., sales and administration; Robert M. Fritz, manager-marketing; Leo Steg, Aerosciences Laboratory; and Logan B. Cowles, manager-nose cone engineering.

• **Young Development Laboratories,** Rocky Hill, N. J., active in design, development and production of reinforced plastic solid propellant rocket motor chambers employing a fiberglass filament winding process.

Representing the company in ARS are Richard E. Young, president; Kenneth W. Smith, vice-president and chief engineer; and Seymour H. Winkler, J. Lowrie McLarty and Robert W. Jamison, project engineers.

• **The International Nickel Co., Inc.,** New York, N. Y., active in development and production of alloys used in the fabrication, propulsion and guidance of rockets and guided missiles.

Company representatives in ARS are F. L. LaQue, vice-president and manager, Development and Research Div.; J. A. Marsh, vice-president and manager, Operations Dept.; E. M. Wise, assistant to the vice-president and manager, Development and Research Div.; J. T. Eash, assistant manager, Research Laboratory; and C. C. Clark, metallurgist, Research and Development Div.

• **Amoco Chemicals Corp.,** Chicago, Ill., active in research, development, manufacture and marketing of solid fuel gas generators.

Named to represent the company in ARS are E. P. Easterday, assistant to the vice-president; Donald H. Ernest, plant superintendent; Paul O. Marti, assistant plant superintendent; George A. Harrington, general manager of development; and Wayne A. Proell, research section leader.

• **American Electronics, Inc.,** Los Angeles, Calif., active in the fields of automatic controls, avionics, engine controls, missile support electronics and missile instrumentation.

Representing the company in ARS are Glenn Ronk, vice-president; Herman Weston, sales support manager; Lou Lenart, marketing support manager; Clem Savant, director of engineering; and Ed Kinney, director of research.

• **CBS Laboratories,** a Division of Columbia Broadcasting System, Inc., New York, N. Y., active in the fields of sensory devices, communications, guidance and control, data processing and visual instrumentation.

Named to represent the division in ARS are Peter C. Goldmark, president and director of research; John W. Christensen, associate director of research and vice-president; Joseph E. Bambara, vice-president of electronic systems; Jerome S. Goldhammer, manager of liaison engineering; and Renville McMann, project engineer.

• **Wyandotte Chemicals Corp.,** Wyandotte, Mich., engaged in research and development of rocket propellants.

Representing the company in ARS are R. A. Graham, director of contract research; E. J. Fujiwara, supervisor of chemical propejects; C. T. Lenk, sec-

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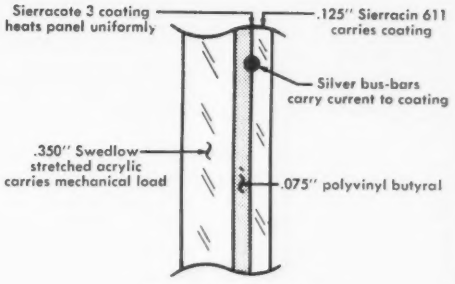
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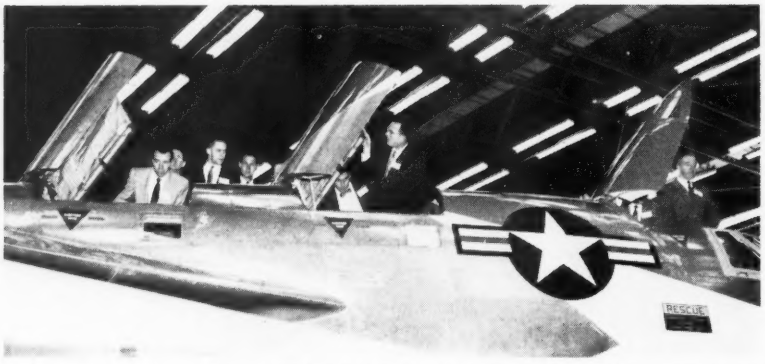


ARS and ASME members attending the jointly sponsored Aviation Conference in Dallas in mid-March had their choice of three field trips. These selected the Convair Ft. Worth plant, where they had an opportunity to see B-58's on the production line.

tion head, organic projects; W. A. Cuddy, head, high-pressure laboratory; and C. W. Tait, supervisor of liquid propellant research.

• **George L. Nankervis Co.,** Detroit, Mich., manufacturer of test equipment and instrumentation.

Representing the company in ARS are Harold M. Cherry, president; Henry W. Grikscheit, vice-president; Vernon G. Converse III, operations manager; Samuel F. Sgriccia, chief engineer; and Kenneth R. Waltz, senior sales engineer.

ARS Urges FCC to Assign Frequencies for Space Flight

The AMERICAN ROCKET SOCIETY has presented a further proposal to the Federal Communications Commission for the allocation of radio frequencies to be used in space flight. The Society had earlier outlined to the FCC the general needs of space flight activities for radio frequencies (January, 1958, ASTRONAUTICS, page 70).

In its latest proposal, ARS urged establishment of three separate classes of radio services to be used exclusively in connection with space flight. The first, an Astronautical Mobile Service, would be set up for communication between space vehicle stations, and between space vehicle stations and stations on earth or in other positions in space.

The second, an Astronautical Radiolocation Service, would be provided as a means of tracking and identifying space vehicles in flight.

The third service would be for Astronautical Radionavigation—intended for the navigation of space vehicles.

Certain existing services, as defined in the Radio Regulations, are adequate for certain types of communications in space, according to ARS. Fixed services, for example, are defined broadly as permitting communications between fixed locations. No limitation is placed on where such stations may be employed, and ARS concludes that fixed stations on positions in space could now be employed in full conformity with current regulations.

The Society's proposals were set forth in comments prepared and filed by Andrew G. Haley, ARS General Counsel. The comments will be considered by the FCC in formulating its proposals to the State Department for revision of the world Telecommunication Convention. An international conference for revision of the convention will be held at Geneva in 1959.

SECTIONS

Central Colorado: "Let's Face Space" was the topic selected by Hans R. Friedrich, assistant chief engineer, Convair-Astronautics, for his address at a dinner meeting of the section early in April. Dr. Friedrich's interesting talk covered his experiences with the V-2 rocket program and the present Atlas program, as well as the future of space travel, and gave section members, as well as their wives and guests, insights into the past, present and future of rocketry.

Cincinnati: Walter T. Olson, chief of the Propulsion Chemistry Div., NACA Lewis Lab., was the featured speaker at the section's April meeting, which attracted a large audience.

Dr. Olson's discussion of rocket propellants centered primarily on exotic fuels. He noted that these fuels, compounded of solid or gaseous elements, pose difficult and unfamiliar problems to the aircraft and engine designer. Engines to burn the fuels must accommodate solid combustion products that cling to combustion and turbine surfaces. Both the possibilities and the problems of these new fuels for air-breathing engines were discussed and illustrated in the lecture.

Such dramatic missions as manned satellites, lunar circumnavigation and moon landing require propellants that can deliver energies greatly in excess of those available in present IRBM's and ICBM's, Dr. Olson noted. He added that electric propulsion devices are also possibilities for space drives, and discussed the research frontier leading to practical application of these new energy systems.

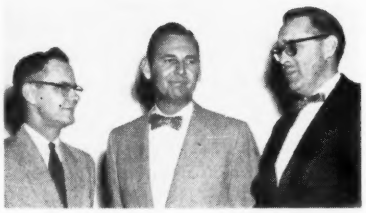
Columbus: The April 1 meeting of the section was held at the Battelle Memorial Institute, with 56 members and guests in attendance. Featured speaker at the meeting was Earl Carter, of the department of physiology and preventive medicine, Ohio State University, who discussed human factors problems associated with extraterrestrial manned flights. Dr. Carter supplemented his talk with very interesting color slides picturing some of the situations which might be encountered. A lively question-and-answer period closed out the meeting.

—Dean L. Pendleton

Detroit: Robert C. Terbeck, assistant chief engineer, Field Support Branch, Chrysler Corp. Missile Div., was the guest speaker at the section's spring meeting. His topic was "Operational Problems of Explorer I." An audience of 250 was present at the meeting, held in the auditorium of the Engineering Society of Detroit. An interesting and lively discussion followed the address and showing of the movie "X Minus 80 Days," which describes the building of the Jupiter-C which launched Explorer I.

—C. A. Gibson

Detroit Section Officers and Guest



Charles Tait (left), Detroit section vice-president, and Lovell Lawrence, section president (right) flank R. C. Terbeck, guest speaker at the group's spring meeting.

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Florida: Tentative program plans for the next six months were discussed at a business meeting April 14. A field trip to The Martin Co. Orlando plant was scheduled for May. At the June 20 meeting, William Zisch, Aerojet vice-president will talk on "Solid Propellant and Future Propulsion." Richard H. Porter of GE, chairman of the U.S. IGY Satellite Panel and former ARS President, will address the July meeting; Howard S. Seifert of Space Technology Laboratories, ARS National Program Chairman and board member, will be the guest speaker in August; Lt. Col. David G. Simons, Chief, Aero Medical Field Laboratory, Holloman AFB, and Chairman, ARS Human Factors Division, will be the September speaker; Hans Friedrich, Convair-Astronautics, the October speaker; and Simon Ramo, president, Space Technology Laboratories, will speak at the November meeting.

Capt. R. F. Sellars (USN), section president, reported that the Education Committee, headed by Capt. Henry C. Paul, is setting up a program of instruction in propulsion, mathematics, electronics and aerodynamics for youngsters interested in rocketry. A first group of such youngsters was organized at Cocoa High School early this year, and others are planned.

Instruction will not include rocket firings, but will instead attempt to direct the interest of the youngsters into educational channels and away from dangerous experimentation.

The meeting closed with the showing of the Wernher von Braun movie, "Conquest of Space," and film clips of Vanguard, Explorer and Thor launchings.

—Maj. Ballard B. Small

Holloman: The regular monthly meeting of the section was held April 1 at the Desert Aire Motel in Alamogordo. The after-dinner portion of the meeting was opened with the introduction of the new base commander of Holloman.

President Knox Millsaps then introduced the distinguished guest speaker for the evening, Fritz Zwicky, world-famous astronomer, author and professor of astrophysics at the California Institute of Technology. Dr. Zwicky spoke on the subject of man-made meteors, tracing the origin and development of the project which last October succeeded in achieving escape from earth gravity.

This endeavor began shortly after World War II, when Dr. Zwicky proposed using shaped charges to fire ultrafast pellets from a V-2 rocket. Spectrographic photos of the pellets' track would then provide valuable data on the composition of the outer atmosphere. A V-2, with pellets installed, was actually launched for this purpose from White Sands in 1946. It reached the desired altitude, but the charges failed to go off.

For the next 11 years, the project saw sporadic bursts of activity and longer periods when, to use Dr. Zwicky's words, "semi-scientific people" in government agencies argued over its feasibility. Naval research scientists somehow became interested, and supported Dr. Zwicky in a successful effort to develop more accurate charges. Then they lost interest again, and the project languished.

However, Dr. Zwicky pushed ahead with help from Cal Tech and Aerojet. One problem was that the pellets, even if successfully fired, would not be hot enough, and so could not develop sufficient luminosity, to be seen. Dr. Zwicky and his co-workers devised various techniques to solve this problem, including what he terms "corruscatives"—explosives that do not fly apart but simply release heat and light. Thanks to these and other developments, Dr. Zwicky was sure his pellets would be self-luminating, even in the thin air at extreme altitudes.

Three years ago the Navy, through the Office of Naval Research, again became interested. For about a year Dr. Zwicky and Navy scientists tried to launch pellet-carrying rockets from balloons off the California coast. A few firings were actually made, but none was really successful. California weather made launching and tracking difficult. An even greater obstacle was the safety precautions that had to be taken lest a pellet accidentally land in San Diego.

Finally, last year, Maurice Dubin of AF Cambridge Research Center, informed Dr. Zwicky that "a little space" was available in the "dunce-cap" of an Aerobee research rocket to be fired from Holloman. The rocket had to be shared with other experiments, and the available space was so little and so awkwardly situated for Dr. Zwicky's purpose that the whole idea seemed "utterly hopeless"—but it worked!

The initial flash from the charges, at 58 miles altitude, appeared as bright as the moon. Each charge propelled one or more particles at speeds as high as 49,000 fps, greater than escape velocity, and the particles were successfully tracked from Mount Palomar Observatory. According to Dr. Zwicky, they are now in elliptical orbits around the sun. They are no longer visible, needless to say, and will not last long, ultimately evaporating in the same manner as comets that come too near the sun.

In conclusion, Dr. Zwickyy discussed possible further developments in this line of research. Improved explosives, such as frozen radicals, could be used to propel much larger par-

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ticles, or could send one all the way to the moon and create a visible impact there. For that matter, Dr. Zwicky held out hope earlier in his talk of throwing something all the way to the nearer stars, and even rearranging our own planetary system. It would be very convenient, he pointed out, if Jupiter were broken up into several hundred more earths, so that people of different tastes could have their own separate planets on which to live.

—Lt. Col. Harry L. Gephart

Indiana: As part of its continuing "Space Flight Seminars," the Indiana Section presented talks on three interesting topics at recent meetings. Astronomy was covered in an address by Robert L. Glick, research assistant at the Purdue Jet Propulsion Center, who discussed the "red shift," the main sequence of stars, cephid variable stars, and various methods of measuring distance, mass and temperature in space.

The March 12 seminar was addressed by Alfred C. Pinchak, also a research assistant at the Center, whose topic was guidance. Inertial guidance was the main theme of the talk, which also covered the principle of the accelerometer and rate gyroscope, as well as the nature of the guidance problem in general, with specific application to missiles. Two movies, "Guided Missiles" and "Search into Space," were also shown at the meeting.

Martin H. Rosenblum, senior research engineer at Rocketdyne, was the speaker at the March 26 meeting. His topic was "Rocket Propulsion with Nuclear Energy," covering design procedures and problems associated with nuclear rockets, as well as difficulties with heat transfer phenomena.

—Alfred C. Pinchak

Niagara Frontier: A series of six Saturday morning lectures has been arranged by the section as part of the Buffalo Museum of Science's program of education for amateur rocketeers. The series, under the heading of "An Introduction to Rocketry," got under way May 10 with an introductory session moderated by Ralph Bloom Jr., Becco Chemical Div.

The May 24 meeting was addressed by Robert Roach, Bell Aircraft Corp., who presented a history of rockets. On June 7, William W. Swenson, Bell Aircraft Corp., will discuss jet propulsion principles; on June 21, Heinz Mueller of Bell will discuss rocket powerplants; June 28, Ralph Bloom and Leo Goldschlag, Food Machinery & Chemical Corp., will discuss propellants; and July 12, Lt. Col. C. E. Parkin Jr., Army Corps of Engineers, and Wendell Moore of Bell will discuss rocket safety, and those attending the lecture will witness rocket firings at the Bell test center.

The April 29 section meeting was addressed by Raymond Ewell, vice-chancellor for research of the University of Buffalo. His topic was education and research in the Soviet Union, and his interesting and timely talk dealt primarily with a 23-day trip through Russia last fall, when he traveled some 5000 miles in the country, visiting 30 universities and manufacturing plants, and gaining a good insight into the Russian educational system and increasing industrialization..

Pacific Northwest: G. Truxton Ringe is the newly elected president of the section. Other officers are: Robert Hildebrand, vice-president; Michael Guidon III, secretary; and Gordon Setterlund, treasurer.

Bliss M. Bushman, engineering department manager at Consolidated Electrodynamics Corp., was the guest speaker at the section's April meeting. He chose as his topic "Data Processing Techniques as Applied to the Testing of Propulsion Engines," and his talk was so interesting that it produced a long discussion period at the close of the meeting.

Emmett Coon of Boeing, immediate past president of the section, introduced the speaker and also announced that the May meeting would be addressed by Brooks Morris of Marquardt, chairman of the ARS Ramjets Technical Committee, whose topic would be "The Age of Ramjets."

—Michael Guidon III

St. Louis: R. Lawrence Maisak, advanced mechanical engineer with Emerson Electric Co. and treasurer of the St. Louis section, was the featured speaker at the group's April meeting. His subject was "Our Neighbor in Space—The Moon," and the lecture was enlivened by an interesting discussion of recently reported evidence indicating the existence of a lunar atmosphere and by a description of those areas which appear to follow cycles typical of some elementary types of vegetation.

—James N. Holsen

San Diego: As part of the National Engineers Week celebration, the San Diego section helped sponsor a "Space Age Dinner," at which Frank Baxter, professor of English literature at USC, was moderator of a panel discussion which brought together a number of leading figures in the field.

Lt. Col. David Simons described his balloon ascent to 100,000 ft. He stated that he had no doubt that man will survive the rigors of space flight, but admitted there were some questions as to how this would be done.

Maj. Gen. J. W. Sessums (USAF), Vice-Commander of ARDC, saw manned military space craft as the next step in the evolution in air power.

Oscar Schachter, director of the U.N. General Legal Division of the U.N., felt freedom of space follows logically from freedom of the seas. He views space flight as an immediate U.N. problem in international peace and security.

Krafft Ehricke, assistant to the technical director, Convair-Astronautics, felt the real reason for space flight is man's thirst for knowledge, while Donald Michael, Dunlap & Associates, in a discussion of the sociological and psychological aspects of the space age, saw little justification, and therefore little probability, of large-scale space flight for colonization, mining, etc.

A very lively panel argument might have followed had not time run out.

At the next meeting, about 30 members and guests heard Tom McMillian, who heads the Special Research Div. of the Navy Electronics Lab., discuss the San Diego Minitrack Station. He noted that weather has produced no noticeable affect on reception of satellite data, and stated that, if stronger

Astrodyne Shows Off for Visitors

More than 50 ARS and ASME members attending the Dallas meeting inspected Astrodyne facilities at McGregor, Tex., on a one-day field trip. Above, Astrodyne's Harold Weiss (far right) outlines steps in sub-assembly and preparation of JATO cases. Below, climax to the trip—demonstration firing of JATO units and large solid rocket booster now under development.

ND FACTS

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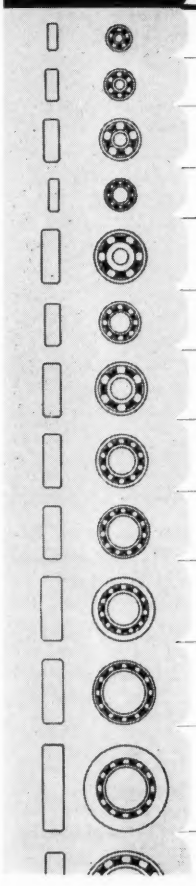	3/64	.0469	5/32	.1562	1/16	.0625	5	1/32	.005
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GM FORWARD FROM FIFTY

NEW DEPARTURE

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NOTHING ROLLS LIKE A BALL

transmitters were used, Minitrack stations could be used to track moon rockets.

On March 13 Mr. Herbert L. Karsch of Aeronutronic Systems, Inc., discussed Project Far Side, before 160 members and guests of the ARS and IAS. He explained the system, aided by slides showing missile components, the balloon, telemetering and instrumentation systems, and showed some amazingly clear movies of the launch at 98,000 ft and discussed some of the data on cosmic rays and magnetic fields.

—Dan Heald

STUDENT CHAPTERS

University of Florida: The student chapter at the university, although only four months old, has grown rapidly, and now has a membership of 46.

Among the first programs that were presented by the chapter was a talk on the Explorer I launching by Capt. Wesley Nichols, project officer connected with missile testing for ABMA, and William F. Sparks, of Pan-American World Airways.

At another meeting, the films "Challenge of Outer Space" and "Road to the Stars" were shown to a group of 500 persons. One of the large auditoriums on campus was used for this meeting.

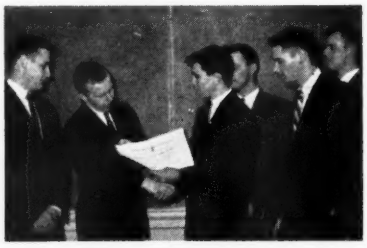
The most recent meeting, on April 10, was attended by more than 200 interested persons. Guests at the meeting were Richard Yordy, Guided Missile Range Div. manager for Pan-American, Capt. Robert F. Sellars USN, president of the ARS Florida Section and Commander, Naval Ordnance Test Unit, Patrick AFB, and Lt. Comdr. E. L. Pietrowski, who discussed operation of the missile test facilities at Cape Canaveral.

At the meeting, Capt. Sellars presented the chapter with its charter, and a film was shown of recent firings at Canaveral. A question-and-answer period followed the showing of the film.

Former president Larry Norby resigned several weeks ago, and the vice-president, Richard H. Jackson, assumed the presidential duties. A new vice-president, William Schilling, was appointed until our next election at the end of this semester. Other officers are Joy Floyd, corresponding secretary; Herb Eisenberg, recording secretary; and Marvin Moss, treasurer. Faculty adviser of the chapter is David T. Williams of the university's department of aeronautical engineering.

—Marvin Moss

Virginia U. Chapter Receives Charter



Dean Roberts (second from left), ARS Director of Public Relations, is shown presenting the University of Virginia Student Chapter charter to president H. Duane Evans. Others in the photo are (left to right): Stuart Croll, secretary; John E. Scott, faculty adviser; Marshall Levy, vice-president; and Melvin Miller, treasurer.

CORPORATE MEMBERS

Aerojet-General's Avionics Div. has moved into a new $1 million engineering building with twelve 100-ft long tunnel laboratories for optical and other experimentation, at its Azusa, Calif., headquarters.

Servomechanisms has moved its Research Laboratory into new headquarters at Goleta, Calif., and reorganized it into separate Basic and Applied Research Laboratories.

Hercules Powder Co. is building a major facility at Bacchus, Utah, for development and production of long-range solid propellant rockets and missiles.

Thiokol Chemical has acquired Hunter-Bristol, manufacturer of ground support equipment for the rocket and aircraft industry, subject to H-B stockholder approval.

In a move to streamline its chemical operations, **Food Machinery & Chemical Corp.** has created two new operating chemical departments, the FMC Organic Chemicals Dept. comprising Niagara Chemical Div. and the Chemicals and Plastics Div., and the FMC Inorganic Chemicals Dept. which includes the Becco Chemical Div., Westvaco Chlor-Alkali Div. and Westvaco Mineral Products Div.

Leach Corp. has formerly opened its new $\$1\frac{1}{2}$ million, 101,000-sq ft Compton, Calif., facility, housing its corporate offices, and the Special Products and Inet Divs. under one roof.

Telecomputing Corp. plans to consolidate its six manufacturing divisions into a single, integrated headquarters on a 77-acre plot in the San Fernando Valley, Calif.

Philco Corp. has jointly launched a shared cost program with Leeds & Northrup Co. to develop, design and build a digital computer with applications in industrial process control and in scientific and engineering computation, including data processing.

Callery Chemical Co.'s Lawrence, Kan., plant will go on stream for boron chemical production later this year.

Norris-Thermador Corp. has undertaken a $650,000 expansion program at its Vernon plant for manufacture of large missile motor chambers.

Bendix Aviation will add a jet starter facility to its Antelope Valley, Calif. installation.

ARS Preprints, Articles Translated into Russian

Many ARS preprints, as well as articles from ARS publications, are finding their way into Russian technical magazines these days, according to Alexander Rosenberg, a lexicographer with the Library of Congress who is now working on a Russian-English glossary of rocket and missile terms.

Many of the translations, Dr. Rosenberg reports, have appeared in a publication called "Express-Information," which regularly publishes important technical papers in a number of different fields.

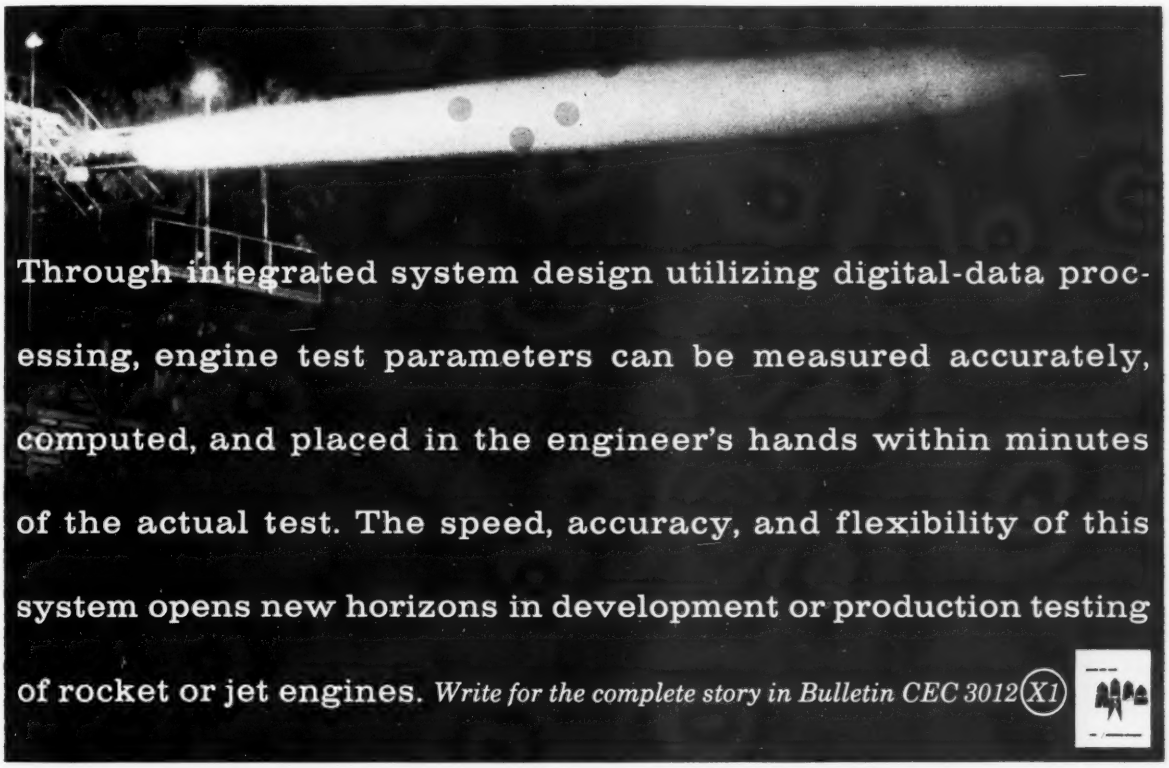
German Rocket Society Marks 10th Anniversary

The German Society for Rocket Engineering and Space Travel celebrated its 10th anniversary in February. To mark the event, the Society issued a special bulletin listing the highlights of its activities during the past decade and containing special congratulatory articles by Wernher von Braun and Eugen Sänger.

Penn State R&D Seminar

The second annual engineering seminar in R&D Management Development will be held July 6–12 at Penn State University. Information is available from the Extension Conference Center, Penn State, University Park, Pa.

computed data in 60 seconds



Through integrated system design utilizing digital-data processing, engine test parameters can be measured accurately, computed, and placed in the engineer's hands within minutes of the actual test. The speed, accuracy, and flexibility of this system opens new horizons in development or production testing of rocket or jet engines. *Write for the complete story in Bulletin CEC 3012(X1)*

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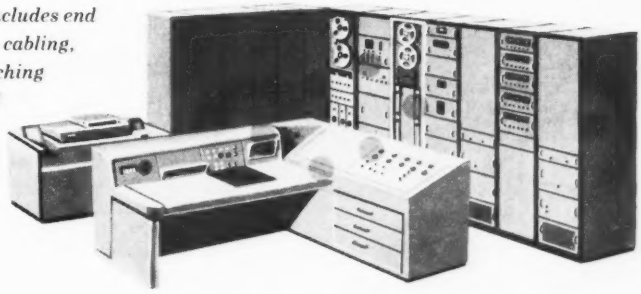

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EXPLOSIVE
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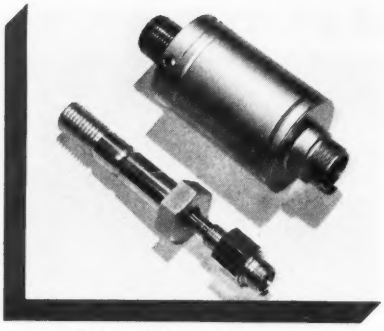
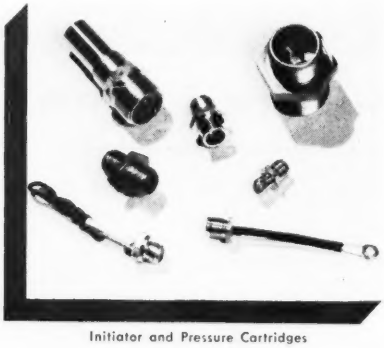


Explosive Bolts and Gas Generators

Mc/S/A explosive ordnance products are used in almost every major aircraft & missile program in the U.S. today. In addition to standard products, the company is geared to the rapid development and manufacture of special units of optimum design and performance.

Solid and Liquid Propellant Igniters



Initiator and Pressure Cartridges

- Explosive Bolts
- Gas Generators
- Initiators & Igniters
- Pressure Cartridges

Write for Detailed Technical Information

"Space Age" Lectures

The last four of a series of lectures on the "Space Age," sponsored by the AF Los Angeles Air Procurement District for military personnel in the area, are being held on successive Monday evenings through June 23 at the Los Angeles Junior College of Business, 1601 S. Olive St. This month's speakers will include Theodore von Kármán and Krafft Ehricke.

Fort Churchill Firings To Resume This Month

Thirty-two more rocket firings, to start in mid-June, are scheduled at Fort Churchill, Canada, before the International Geophysical Year program ends, the National Academy of Sciences reports. A total of 41 rockets have been launched since the IGY began in July 1957, for the purpose of exploring the upper atmosphere between 46 and 160 miles. Early indications are that 22 of the 23 firings in 1958 produced the desired scientific data.

Data now being processed are expected to throw new light on the altitude of electric currents responsible for disturbances in the earth's magnetic field during an aurora, and on the nature, extent, and location of the electrons and ions at high altitudes, governing factors in radio transmission.

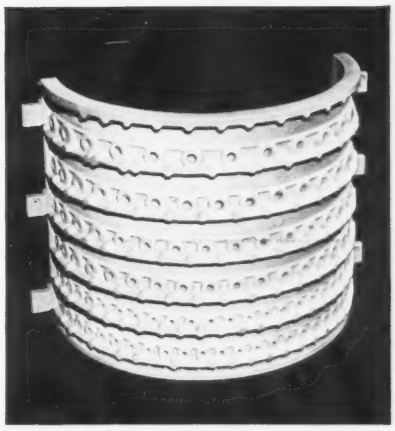
Rocket vehicles used or planned are the Loki Phase II-Dart, Nike-Cajun and Nike-Asp, and the Aerobee and Aerobee-Hi which are the largest, and carry 150 lb of instrumentation.

SRI Uses Arc-Image Furnace For Fuel Ignition Study

Measurements of the quantity of energy required for ignition of solid propellants are being successfully conducted at Stanford Research Institute with an arc-image furnace, chosen because very short exposure times of high-flux radiant energy could be applied. The heart of the SRI furnace is a combination of a motion picture projection lamp and a secondary mirror, based on the concept of a double-ellipsoidal system of mirrors originally developed by National Carbon Co.

In operation, energy originating at the arc source is directed to, and reflected from, a secondary mirror to a specimen at the image. Heat flux up to about 160–180 cal/cm^2-sec (blackbody temperature of about 3450 K), and temperature control between −30 and 200 F for incoming streams of various gaseous compositions, are provided.

Zirconium, thorium, cerium . . . strange names for little known, little used elements. But add them to magnesium, and a new family of metals appears. Preserving the high strength-weight ratio of the featherweight metal, they add high-temperature properties that have proved a necessity in high performance aircraft and missiles. A specialist in light metals casting, Rolle knows these alloys as you know the back of your own hand.



how to save weight at high temperatures

an introduction to the magnesium-rare earth-thorium alloys

One-fourth the weight of steel . . . two-thirds the weight of aluminum . . . magnesium has carved a featherweight niche for itself in modern materials engineering.

But the reputation won by the magnesium-aluminum zinc alloys was won at room temperatures. Where high temperatures obtain, the "structural" alloys are no longer structural, and the lesser known "premium" group comes into its own.

These alloys, providing excellent high temperature properties and creep resistance to 660F, are also characterized by

- uniform strength of varying cross-section
- high fatigue strength
- low notch sensitivity
- freedom from microporosity
- good stress rupture characteristics
- good founding qualities

Naturally, properties vary within the group, but a rough comparison of individual advantages can be drawn.

a profile of the "premium alloys"

ZK51A and ZE41XA are superior, fine grained alloys with high yield strength and ductility, excellent fatigue properties, low notch sensitivity, and they are pressure tight without impregnation. Alloy ZH62XA offers these same general properties but is stronger than ZK51A. The room temperature strength of ZH62XA is combined in a relatively new alloy, ZH42, with creep resistance to 480F.

Complete freedom from microporosity, excellent founding properties, and low heat treating temperatures, characterize EZ33A, a magnesium-zirconium-cerium alloy. Like ZH42, EZ33A resists creep to 480F, and possesses good tensile properties at both normal and elevated temperatures.

HZ32A, perhaps the most important alloy of the series, contains thorium rather than cerium. Equal to EZ33A in strength, founding properties, and heat treating characteristics, it resists creep to 660F.

ideal for engine castings

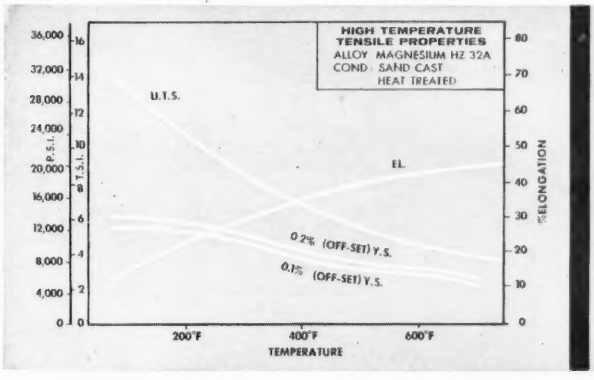
Though each of these "premium" alloys offers specific advantages, the benefits of HZ32A have undoubtedly been most impressive. Its unique heat resistance properties permit weight savings in stressed turbine engine parts with magnesium castings for the first time. A typical example is the part illustrated above . . . a jet engine compressor housing . . . sand cast by Rolle in HZ32A. Success of this alloy in such applications can be inferred from the two graphs—High Temperature Tensile Properties and Creep Resistance For Specified Plastic Strains.

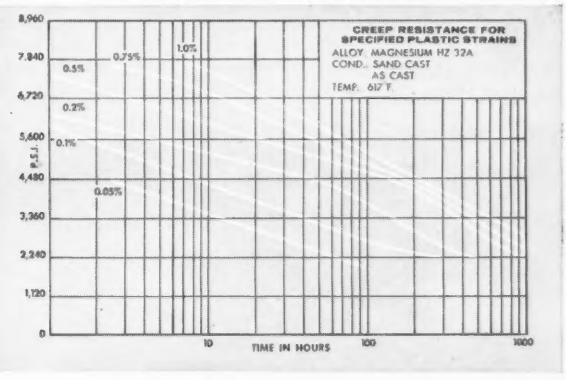
maintaining specified properties

Chances are you spend hours . . . even days . . . studying the "book" specifications of a metal before you design it into a part. But the book you've been working with too often gets thrown out the window with the first production run. Getting the most out of the premium alloys and into the cast part is often a difficult task, but we feel we're in an ideal position to do just that. Sand, shell, and permanent mold casting the *light metals* . . . and *only* the light metals . . . is our business.

fifty-eight page engineering manual

A considerable amount of data on the design properties of the aluminum and magnesium alloys can be found between the covers of our light metals casting manual. We'll gladly send you a copy on letterhead request. Write Rolle Manufacturing Company, 319 Cannon Avenue, Lansdale, Pa., or call ULlysses 5-1174.





ROLLE

Drones Grow with Weapons

(CONTINUED FROM PAGE 30)

phase, and, as mentioned, may for this phase be considered a part of range instrumentation. The evaluation phase of development involves integration of system elements, proof of system performance, and firings against the kind of attacker that the weapon system is expected to encounter. Emphasis shifts to use of the target for simulating this attacker, which may take on different forms. The target system for the evaluation phase will therefore probably require much flexibility, or differentiation into a family of targets.

During production, the target, part of a training program of mockups, models, handbooks, etc, forms the final step in the learning process, introducing a crew with newly acquired "book learning" to the real problems of the field. Here, it is enough that the target activate the detection, acquisition and guidance elements of the weapon system. Consequently, this training can sometimes be accomplished with subperformance targets.

During operational evaluation, the aerial target simulates the expected attacker most realistically and provides the means to measure the total effectiveness of the weapon system, including the training of the combat crew. The target in operational evaluation and in later maintenance exercises must show considerable refinement of performance, particularly in simulating flight paths and tactics.

The sum of these requirements and the many different functions demanded of an aerial target give it variety of form and performance, which can be seen in the many drones now making their appearance.

Based on a paper presented at the ASME-ARS Aviation Conference in Dallas, Tex., March 17-20, 1958.

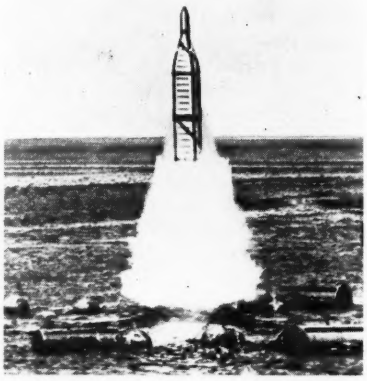
Polaris—One U. S. Answer to Sneak Attacks

Defense Secy. Neil H. McElroy and the Navy see eye-to-eye on the fact that Polaris-armed subs could be "an important deterrent force," and a revolutionary weapon in any future warfare. McElroy made his statement during recent testimony before a Senate committee.

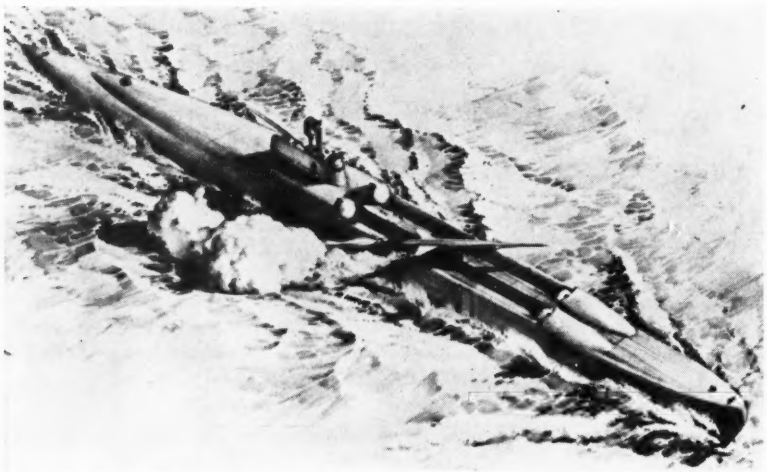
As envisioned by the Navy, nuclear-driven subs armed with Polaris missiles could ring Eurasia and hit every major Russian target. The idea was lent substance by Rear Adm. Hyman G. Rickover, who said subs could hide under the Polar icecap awaiting a signal to move into action, as proved by the Nautilus last summer when it cruised under Arctic ice for $5\frac{1}{2}$ days.

The Navy also claims a submarine-fired Polaris fleet would be far less costly than maintaining SAC bomber fleets or building launching sites for land-based IRBM's and ICBM's. In addition, the Polaris can be fired 1500 miles from ocean depths without chance of counterattack.

Target date for the Polaris missile (28.5 ft high and 4.5 ft girth) has been set ahead from 1962 to possible firing of the complete missile at Cape Canaveral, Fla., in the fall of 1959. Educated guesses about the highly secret Polaris-launching sub are that it will carry 16 missiles standing upright in twin banks of eight.



Dummy Polaris rises from ocean depths during Navy development tests of an underwater launcher for the missile.



Defense Dept. artist's drawing shows guided missile poised for firing from nuclear-powered missile submarine Navy is building.

AFMDC Summer Programs

Problems affecting this nation's research and development effort will be explored by scientists from the U.S. and Europe at the regular annual summer study program getting under way this month at the AF Missile Development Center, Alamogorda, N. Mex. A second program starting June 2 will consist of a series of two-week lectureships, sponsored in conjunction with the University of New Mexico.

Project Space Track

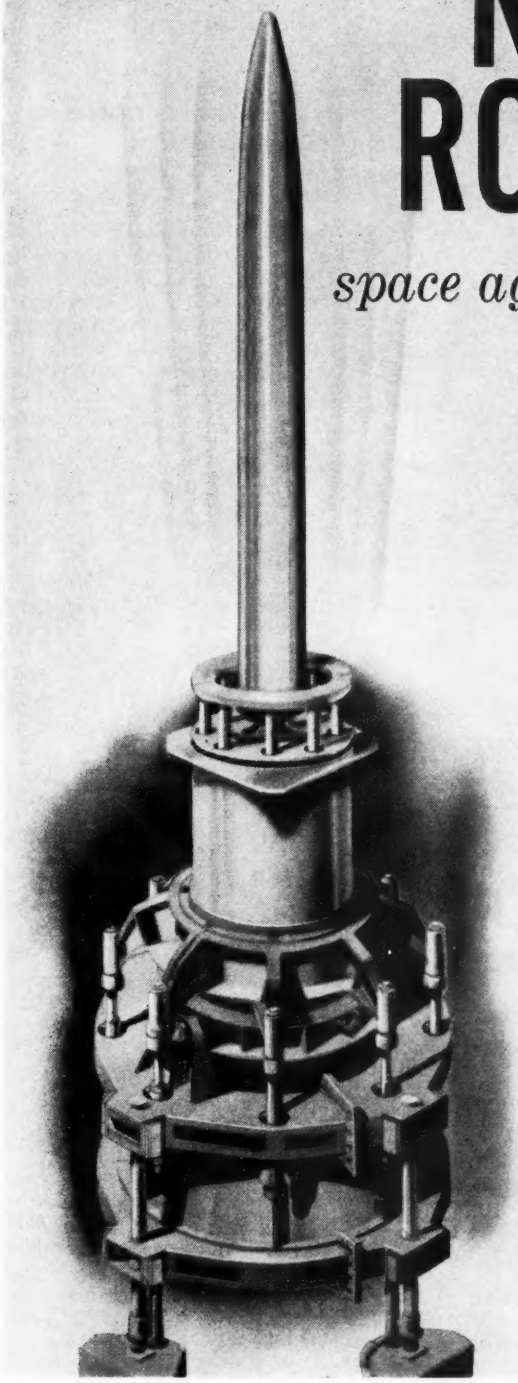
The Air Force has revealed that it initiated Project Space Track last November to observe and study all earth satellites as a means of gathering environmental data. Established by ARDC, the project has its headquarters at AF Cambridge Research Center, Bedford, Mass., and is under the direction of the Geophysics Research Directorate of the center. Observational data obtained through the project are exchanged with the Smithsonian Astrophysical Observatory.

Reaction Motors Pushes X-15 Engine Program

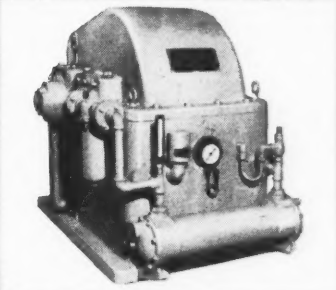
Reaction Motors has stepped up development of the liquid propellant rocket engine for the X-15 research aircraft. First test flights of the ship are scheduled for next year. A new 100,000-lb-thrust test stand, to be used for accelerated testing of the Pioneer rocket engine the company is developing for the X-15, is being built by RMI.

ROCK 'N ROLL

space age style



Two Western Gear high speed units, as below, models 95HS90, 700 HP, 1780/4500 RPM and 160HS110, 2250 HP, 1780/6600 RPM are the muscles that transmit the power on this Loewy-Hydropress ship motion simulator being built for the U.S. Navy for missile testing.



A missile that is designed to be launched from a ship at sea, such as the Navy's "Polaris" must be tested under extreme conditions to guarantee accurate launching of the missile.

When Loewy-Hydropress contracted to build a missile test stand simulating shipboard motion for the Naval Ordnance Test Unit at Cape Canaveral Test Annex, they turned to Western Gear for the "muscles"... 2 high speed units that help simulate the rolling and pitching conditions equal to 16 foot waves. Like many major manufacturers, Loewy-Hydropress knows that any problem involving the transmission of motion or torque will be efficiently solved by Western Gear engineers, who combine 70 years of experience with a wide range of standard and specialized equipment designs to come up with the right answers in a hurry.

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Ionosphere Probe Tied To Atlas Firings

Space Technology Laboratories scientists will conduct ionospheric probes through use of Doppler radar and signals emanating from the Atlas ICBM. By investigating the difference in frequencies recorded by the radar sets, based on knowledge of the Atlas' speed and altitude, it is hoped that electron density measurements perhaps 10 times more precise than were previously possible may be obtained.

Inertial Guidance Progress Revealed by ARDC

ARDC has made public some of the means used by Autonetics Div. of North American Aviation to prove that automatic inertial navigation was practical. The first breakthrough, ARDC says, occurred in May, 1950, when an all-inertial autonavigator accurately guided a C-47 to a preselected point, effected a 180 deg turn and returned the plane to its base. Four years later, a lightweight inertial system in an F-86 Saber Jet underwent a series of aerobatic flights during which the platform remained stable and showed no error trend. This system was delivered to the AF in November 1954.

Another milestone was reached in April, 1955, when a $13^1/_2$-hr transcontinental flight by a T-29 from Los Angeles to Patrick AFB, Fla., proved that a stellar-inertial system could operate successfully and accurately under routine flight conditions.

Then-and-Now

Fred S. Miller, manager of solid rocket propellant production at Aerojet-General and one of the originators of JATO, holds one of 12 original JATO units used in the first successful jet-assisted take-off for aircraft in 1941. Behind Miller is a huge Aerojet rocket engine recently developed for the Navy.

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people in the news

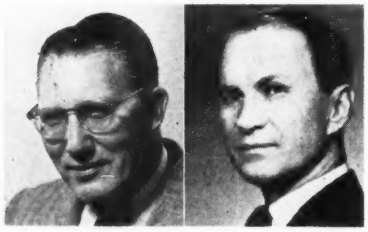
APPOINTMENTS

Capt. Robert C. Truax (USN), immediate past president of ARS, has been assigned to the Advanced Research Projects Agency of the Department of Defense. He was formerly with the AF Ballistic Missile Div., Inglewood, Calif.

Ferguson **Ritchey**

Newly appointed officers of Thiokol Chemical Corp. are **H. R. Ferguson,** vice-president and treasurer, named executive vice-president; and **H. W. Ritchey,** technical director, Rocket Div. and ARS board member, named vice-president.

H. D. Lowrey, former director of manufacturing, Defense Operations Div., Chrysler Corp. Missile Div., has been named director of operations; **Charles W. Snider,** former manager of government relations representatives, becomes director of government relations for the division.



Lowrey **Gavin**

Lt. Gen. James M. Gavin (USA-Ret.), former Army R&D chief, has been elected vice-president and a director of Arthur D. Little, Inc.

Edward C. Wells, Boeing vice-president, will head the company's newly formed Systems Management Office, with overall responsibility for weapon systems. **George Stoner,** former Bomarc weapon system manager, becomes general manager, while **Harlow J. Longfelder,** previously chief of preliminary design, Seattle Div., has been named systems engineering director.

At Boeing's Pilotless Aircraft Div., these appointments: **Robert H. Jewett,** former chief engineer, to the new post of assistant general manager–chief engineer; **Harvey Gunning,** former missile test chief, to head, Sales and Systems Test Dept.; **George Snyder,** former chief project engineer, to engineering manager, Engineering Dept.; **John D. Alexander,** former advanced air defense system engineer, to advanced projects engineering manager; and **Robert J. Helberg,** former Bomarc project engineer, to Bomarc weapon system manager. **Elliot Mock,** former preliminary design engineer, succeeds Helberg, while **E. W. Smith,** former preliminary design engineer, airborne missile system group, moves up to head preliminary design.

Charles Benton Jr., former director of marketing programs for the Data Processing Div. of IBM, has been appointed general manager of the company's Military Products Div.

Benton **Hauser**

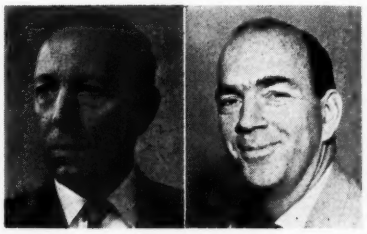
George H. Hauser has been named assistant to the president of Republic Aviation Corp. New Republic consultants are: **Antonio Ferri,** Brooklyn Polytechnic Institute; **Charles S. Draper,** head of the MIT Aeronautical Engineering Dept. and director of its Instrumentation Lab.; **Winston Bostick,** Stevens Institute of Technology; and **John L. Barnes,** University of California.

Callery Chemical Co. has appointed **Thomas R. Kendrick III** technical manager of its Lawrence, Kan., Div.

Robert Taggart, former director, Experimental Test Div., Reed Research, Inc., has been elevated to the new post of technical administrator.

Alfred T. Loeffler, vice-president, Food Machinery and Chemical Corp., has been named general manager of the new Organic Chemicals Dept. and will be assisted by **R. H. F. Dade,** named a vice president of the Chemical Divs. **Frederick A. Gilbert,** former manager, Becco Chemical and Westvaco Chlor-Alkali Divs., has been made general manager of the new Inorganic Chemicals Dept., while **Donald C. Oskin** will be assistant general manager and becomes a vice-president of the Chemical Divs.

Henri Busignies, has been named president of the newly consolidated IT&T Laboratories. One of the founders of Federal Telecommunication Laboratories, he became its president in 1956.



Busignies **Sweetman**

Willard Sweetman Jr., former assistant general manager, Sundstrand Turbo Div., has been upped to plant manager. **David MacMorris** has been appointed eastern representative of the division's newly established office in Washington, D. C., while **K. A. Groff** has been named Washington district representative for the Sundstrand Aviation and Turbo Divs.

Col. William C. Farmer (USA-Ret.) has been named weapons systems manager, Solar Aircraft Co.

Thompson Products vice-president **Edward P. Riley** heads the company's new Tapco Group, which integrates its Jet, Accessories and Pneumatic Divs.; West Coast Div. aircraft operations; and Cleveland Electronics Div. in a move designed to expand the company's activities in the systems field. **Stanley C. Pace,** former manager of the Jet Div., will assist Riley. **Pierce T. Angell,** former manager of the Accessories Div., will direct the group's central engineering function, while **John H. Shaffer,** formerly Riley's assistant, will head the coordinated sales section.

William D. Morton Jr., former project engineer, USAF Aero Medical Laboratory, Wright ADC, has joined the staff of Sierra Engineering Co.

Edward I. Brown, former chief engineer of the Vickers Torrance plant, Aero Hydraulics Div., has been appointed director of engineering, Machinery Hydraulics Div.

J. E. Jonsson and **Patrick E. Haggerty** have been elected chairman of the board and president, respectively, of Texas Instruments. Jonsson has been serving as president, Haggerty as

executive vice-president and director.

Frank G. Denison has been appointed director of the newly formed Aeronautics Dept. of Interstate Electronics Corp.; **Albert A. Hodgson** will be chief of analysis.

Frederick I. Ordway III has joined National Research and Development Corp. as vice-president and director of the new Astronautics Div. He formerly was executive vice-president of General Astronautics Corp.'s Huntsville office.

Ordway **Burtness**

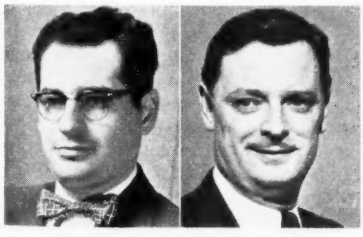
Roger W. Burtness has been appointed manager of engineering and research, Stewart-Warner Electronics Div.

Harry E. Rice has been appointed manager, Special Products Div., Networks Electronic Corp.

Sun Chemical Corp. has appointed **Arthur L. Davis** vice-president of its Electro-Technical Products Div.

Robert Strich, former product engineering supervisor, Cannon Electric Co., has been promoted to chief engineer, Los Angeles Div.

Herman Epstein, former manager, Digital Communications Dept., Burroughs Research Center, has joined Tele-Dynamics as vice-president in charge of engineering.



Epstein **Howell**

Frederick W. Howells, former manager of military sales for the Columbus Div., North American Aviation, has been appointed manager of Singer Mfg. Co.'s newly created Military Products Div.

David G. Simons, chief, Aero Medical Field Laboratory, AF Missile Development Center, Holloman AFB, N. M., and chairman of the ARS Human Factors Committee, has been promoted to Lieutenant Colonel.

Capt. Grayson Merrill (USN-Ret.) has been appointed general manager, Guided Missiles Div., Fairchild Engine & Airplane Corp.

William A. Stevenson, former chief engineer of advanced missile projects, Convair, has joined Lockheed's Missile Systems Div., where he will direct design of the Navy's Polaris.

Bob A. Wilson has been named assistant to the missile products manager, Exide Industrial Div., Electric Storage Battery Co.

Thomas A. Hussman Jr. has been appointed director of Psychological Research Associates new Encino facility. **George A. Peters** becomes a research associate.

Sylvania Electric Products has appointed **Merle W. Kremer** and **Gerald L. Moran** vice-president and general manager of the Parts Div. and Chemical and Metallurgical Div., respectively. Both were formerly general managers of the divisions. **F. J. Anderson,** former assistant manager, Avionics Lab., has been named manager of the newly formed Data Processing Lab., while **Richard W. Couch,** former business manager, Sylvania's Waltham, Mass., labs, becomes project manager of the AF Ballistic Missile Early Warning System program.

George H. Singer has been named general manager of the new Microwave Div. of Kearfott Co. **A. L. Lisle** and **W. A. Hughes** are sales and contract manager and chief engineer, respectively.

Coleman Engineering Co. has named **Roger Farnham** to its Washington, D. C., staff.

Gulton Industries, Inc., has named **Bela M. Roney** a consultant in welding technology, primarily for its Advanced Development and Systems Dept.

Maj. Gen. Harry Reichelderfer, (U.S.Army-Ret.), has been appointed assistant director, Southwest Research Institute.

Capt. Howard Thomas Orville, retired chief Navy aerologist, has been named to the newly created post of vice-president, Beckman & Whitley, Inc. He will assist in long-range scientific and technical planning.

Alfred B. Focke has been appointed chief scientist, U. S. Naval Air Missile Test Center, Point Mugu, Calif., and will act as principal adviser to Rear Adm. Jack P. Munroe, commander of the center.

Abraham I. Dranetz, former director, engineering, Gulton Industries, has been appointed general manager of the new Glennite Instrumentation Div.

HONORS

Maj. William M. Stowell, assigned to the Army Command and General Staff College, Ft. Leavenworth, and formerly the sole Army member of the ARS Holloman Section, has been cited by the Army for outstanding interservice cooperation and accomplishment while serving as chief of the Range Instrumentation Development Div. at Holloman.

Gregory K. Hartmann, technical director, U. S. Naval Ordnance Lab., has received the Defense Dept.'s Distinguished Civilian Service Award for "brilliant leadership and accomplishments."

Roger E. Matzdorff and **Clifford E. Newberry** of Marquardt Aircraft Co. have been awarded the 1957 Manly Memorial Award of the Society of Automotive Engineers, made annually to the author of the best technical paper relating to theory or practice in the design or construction of, or research on, aeronautic powerplants or their parts or accessories.

T. Claude Ryan, president of Ryan Aeronautical Co., has been voted a Horatio Alger Award for 1958 by the American Schools and Colleges Assn.

DEATHS

George V. Slottman, vice-president, research and engineering, Air Reduction Co., Inc., and a very early member of the AMERICAN ROCKET SOCIETY, died in New York City recently at the age of 54.

Dr. Slottman was a professor of chemical engineering at MIT from 1927 to 1930, when he joined United Steel Companies, Sheffield, England, as chief combustion engineer and iron works manager. He joined Air Reduction in 1934, becoming director of research and engineering in 1949 and vice-president in 1952.

Directly associated with the development of oxygen cutting processes since 1924, Dr. Slottman donated the first lox tanks used in early ARS rocket experiments.

Mark M. Mills, deputy director of the University of California Radiation Lab., Livermore Branch, and ARS member, died recently in a helicopter crash at the Eniwetok Proving Ground. Dr. Mills was engaged in a mission related to the forthcoming Hardtack test series at the time of the accident.

William E. Douglas, retired assistant treasurer and director of Douglas Co., died at the age of 95. He was the father of the Douglas board chairman, Donald W. Douglas, and grandfather of the present president, Donald W. Douglas Jr.

Druggists Act to Ban Propellant Sales

State and local pharmacist associations throughout the nation, alarmed over the rising accident rate due to rocket experiments by youngsters, are acting to ban sales of propellants. The District of Columbia Board of Pharmacy took the first step in this direction, and the action has been hailed by many other state and local druggist groups.

The accompanying poster was printed in Drug Topics, a national druggist business paper, for use by pharmacists in curtailing such sales.

Design Criteria

(CONTINUED FROM PAGE 29)

Certain liquid oxidizers do have temperature limitations, but more than one liquid combination can operate between −65 and 160 F, the common service initial-temperature limits.

7. *Logistics.* There are some applications in which logistic considerations place solid propellants in competition with liquids. Where storable liquid propellants can be utilized, however, or where long duration requirements limit performance capability of the solid, liquid propellants appear to have the advantage.

The next step is propellant selection. Candidates are liquids that can be stored in a pre-packaged system. Selecting a suitable fuel is relatively simple, however, compared to selecting an oxidizer.

Most rocket fuels have acceptable performance, combined with good temperature and handling characteristics. Oxidizers, on the other hand, must be carefully considered from all standpoints. Every oxidizer presents some sort of compromise.

Chlorine trifluoride (ClO_3F), for example, has high density but fairly low specific impulse. Hazards of handling, relatively high vapor pressure and limited availability rule out its use except where low volume is the utmost consideration. Perchloryl fluoride (ClF_3), actually a liquefied gas, boils considerably below room temperature, introducing a penalty in oxidizer tank weight imposed by high vapor pressure at elevated temperatures. In combination with the undesirable exhaust products, this leads to its rejection for drones. Nitrogen tetroxide (N_2O_4), of good performance and non-corrosive when dry, shows both undesirably high freezing point and vapor pressure. Red fuming nitric acid (HNO_3) possesses good performance and wide temperature operation. Its toxicity is ameliorated by low vapor pressure, and its high corrosivity can be inhibited for adequate storability.

The most suitable storable oxidizer appears to be inhibited red fuming nitric acid (IRFNA) in this approximate composition: 82 per cent HNO_3, 15 per cent NO_2, 2 per cent H_2O and 1 per cent HF (corrosion inhibitor).

Various Fuels Can Be Used

The oxidizer chosen, fuel selection becomes relatively straightforward. A large number of fuels might be utilized—boron fuels, hydrocarbons, hydrazine, unsymmetrical dimethyl hydrazine (UDMH) or aliphatic amines. Hydrazine appears best with IRFNA from the standpoint of specific impulse and density, but hydrazine without additives has a high freezing point. UDMH has better physical properties over the temperature range, and has comparable performance, good combustion with IRFNA and satisfactory properties for regenerative cooling.

IRFNA/UDMH appears to be the storable bipropellant to use. The chart on page 28 gives characteristics of IRFNA/UDMH compared with some other possible propellants in terms of specific impulse (I_{sp}) and specific impulse times density ($I_{sp}d$), the latter being useful to compare propellant tank size needed for some particular total impulse (thrust times duration).

The oxidizer and monopropellant, hydrogen peroxide, being in a class by itself, must be given special consideration.

The performance of jet fuel and 90 per cent hydrogen peroxide is nearly equivalent to that of IRFNA/UDMH. The excellent combustion of hydrogen peroxide with all hydrocarbon fuels, its convenient monopropellant decomposition for simple and flexible gas generation, and its low hazard to personnel are very attractive, particularly where safety is a prime consideration. If a limited temperature control for storage could be provided, peroxide would probably be preferable to IRFNA as an oxidizer. A high freezing point and need for venting, however, restrict its use in certain applications.

Where low performance can be tolerated, monopropellants offer a simple and cheap approach to drone powerplants. Hydrogen peroxide is a particularly attractive monopropellant, owing to the high reliability attainable with existing state of the art components, short and relatively inexpensive development, and growth

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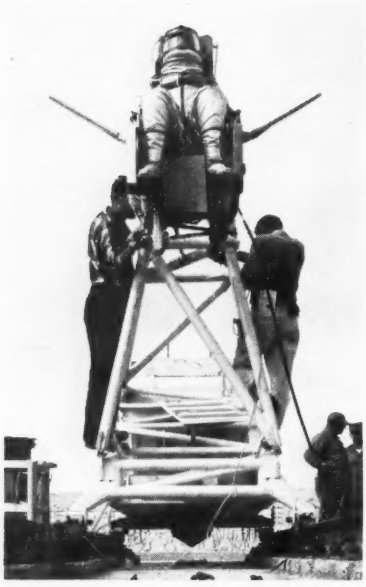
X-15 Dummy



Dummy dressed in X-15 pressure suit is secured into ejection seat atop a boom extending from a stripped down F-107 sled powered by a series of Aerojet solid propellant rockets during windblast tests at AF Flight Test Center's High Speed Experimental Track, Edwards AFB, Calif.

possibilities by incorporation in a bipropellant system.

With propellants selected, the designer next turns to the engine system. A pressurized system is a clear choice over the relatively more complicated turbopump feed in terms of cost and simplicity. The pressurant employed is nitrogen gas, stored at 2000 to 5000 psi.

Suitable propellant tank and thrust chamber pressures are now determined. Depending upon the particular configuration requirements, a simple optimization of minimum weight may be performed to determine compromise values. For the simple pressurized-feed case, total system weight will include the weight of propellants, tanks, engine hardware and pressurizing gas. For small drones, minimum system weight occurs at chamber pressures of 200–250 psia. This chamber pressure, then, sets design parameters at appropriate values.

Typical Design Approach

Alternate bipropellant and monopropellant drone systems, using the propellants discussed earlier, illustrate typical design approaches. As described in the table, the general requirements for the two systems are the same. The drawings on pages 28 and 29 show the systems schematically.

The bipropellant system with IRFNA/UDMH would be completely storable and prepackaged. Burst diaphragms isolate the propellants within the tanks and thus eliminate corrosion in line components. Cheap, squib-actuated shutoff valves initiate pressurization and select thrust level. Propellant tanks are fore and aft of the nitrogen bottle to minimize CG shift and decrease the possibility of propellant mixing if a leak occurs. Optimized tank pressure is approximately 350 psia. The only moving parts are the five valves and a gas pressure regulator. Three valves could control a system with only one thrust level. The sustainer utilizes a lightweight regeneratively cooled chamber and nozzle; the booster phase, being of short duration, employs an uncooled nozzle, although the weight increase of a cooled nozzle is not appreciable.

The monopropellant system employs catalytic decomposition of the peroxide and a gas-pressurized feed system. It requires no regenerative cooling because chamber temperatures are about 1300 F. Separate chambers provide boost and sustainer thrust. Control is simple. A burst diaphragm isolates the propellant in the tank, a simple squib valve releases the stored high-pressure nitrogen, and two squib valves control propellant flow to the two thrust chambers. The nitrogen is regulated down to the appropriate propellant tank pressure, between 200 and 400 psia. Tank construction represents a high-production concept utilizing two identical impact-extruded halves, flash-welded together.

The bipropellant system gives higher performance, a more compact package, smaller propellant and pressurizing-gas volumes, and significantly lower total weight. But this is not the whole evaluation.

Final Evaluation

Cost is the prime factor in determining which system is to be chosen. Some costs are fixed and must be amortized over a given number of missions; others may be directly related to the mission requirements. Summarized here are some factors affecting relative cost of bipropellant and monopropellant systems.

1. *Development.* A bipropellant system is estimated to cost three times as much as a comparable monopropellant system. Cost of developing the propellant itself is fixed and relatively minor.

2. *Fabrication.* Assuming equally available facilities, the bipropellant system should cost about 40 per cent more than the monopropellant.

3. *Overall cost as a function of engine cost.* The lower performance monopropellant engine system increases drone size and weight. Tanks are included in engine system designs. However, additional missile costs would be related to increased control requirements and resultant general missile growth. Where the ratio of engine cost to overall cost is high, this effect is minimized, and the monopropellant system is more attractive.

4. *Field handling.* Items to be considered are facilities, maintenance and overhaul, and personnel and equipment required for operation. As a storable propellant, peroxide can be competitive with IRFNA/UDMH except for a slight increase in cost connected with additional surveillance requirements and low-temperature conditioning equipment. If field loading of peroxide is employed, the field handling and facilities cost, as compared to the storable acid system, would increase appreciably unless suitable equipment was already available. Maintenance costs reflect system simplicity and reliability in terms of rate of deterioration and operating life of parts, as well as the complexity of system checkout prior to flight. Here, the monopropellant system shows a slight edge over the bipropellant.

5. *Parts replacements and malfunctions.* Differences in costs for replacements and malfunctions would be related to the number of missions and operational reliability. Slightly lower costs would be experienced with the monopropellant system.

Choosing an appropriate propulsion system for a drone, it is apparent, cannot be narrowed to cut and dried decisions. The problems discussed here are typical of those faced by the drone designer and propulsion-system analyst.

Based on a paper presented at the ASME-ARS Aviation Conference in Dallas, Tex., March 17–20, 1958.

AF Expands Overall Missile Training Program

The Air Force has expanded its overall missile training program in support of the rapid development of missile systems and the increased number of units being activated to handle the weapons. The program covers the Atlas, Titan, Thor, Jupiter, Snark, Mace-Matador and Bomarc systems, and consists of both individual and crew training. The Air Training Command is responsible for the former, while individual commands conduct crew training.

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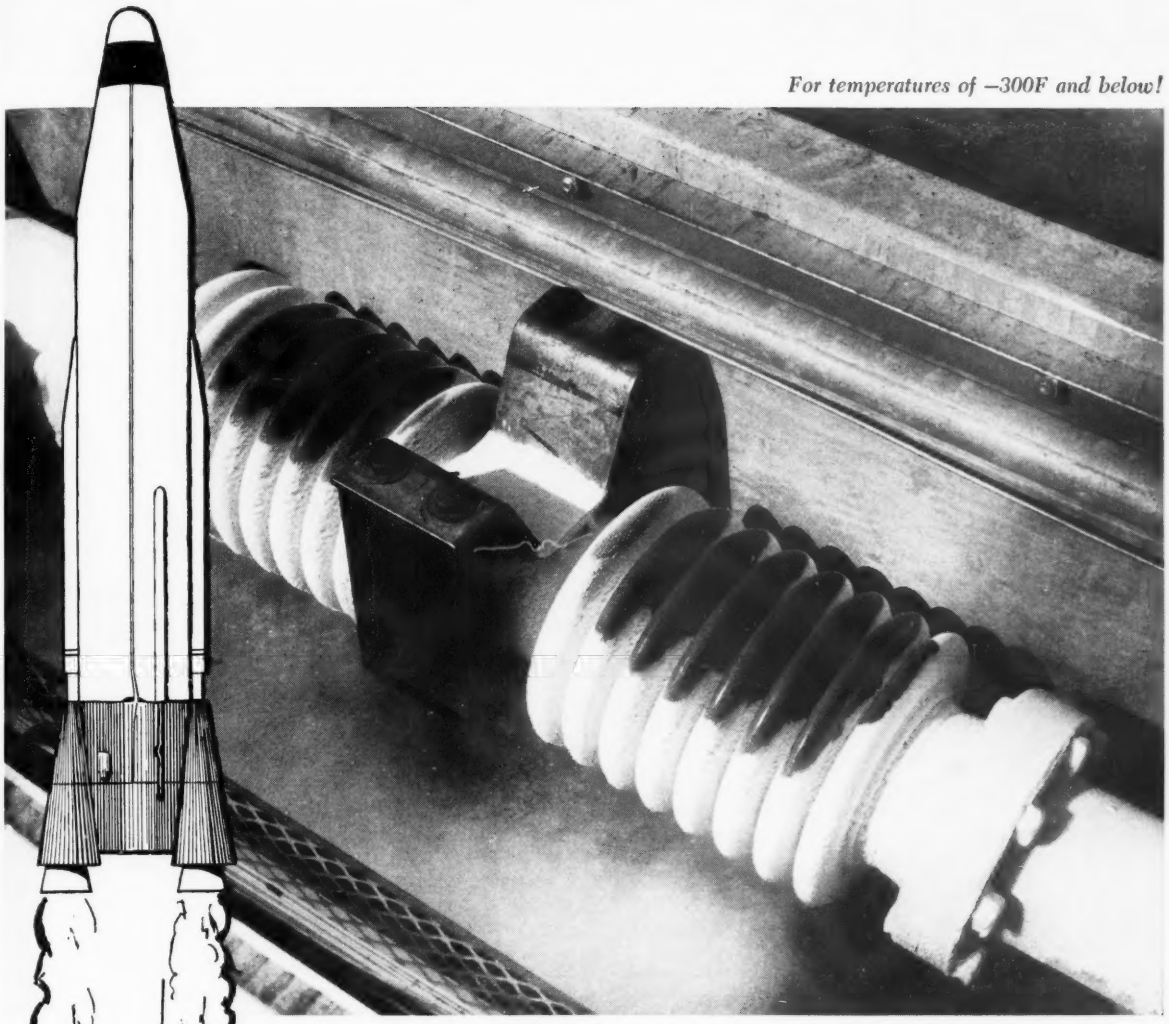

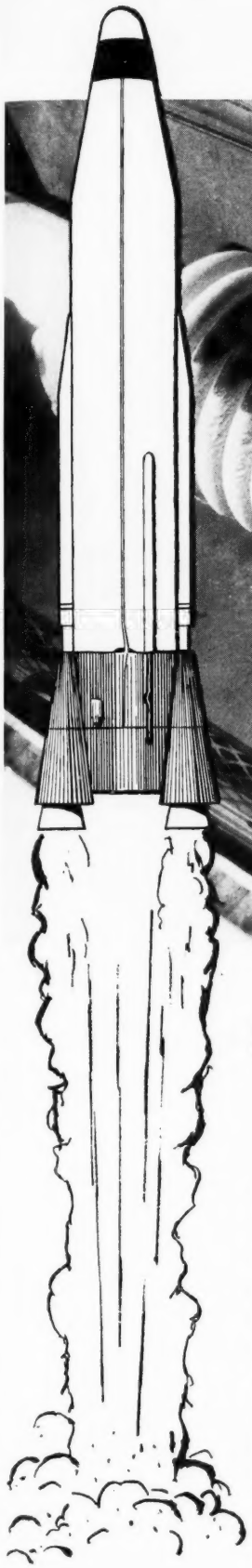

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the international scene

BY ANDREW G. HALEY

EARLY in March, I flew to Prague, where I was the guest of Rudolf Pesek, head of the department of aero- and hydrodynamics at the Technical University in that city. There is as yet no Czech member society in the IAF, but I had for some time been corresponding with leading Czech scientists in an effort to arouse interest in such a society. While in Prague, I had an opportunity to discuss the matter at some length with a number of Czech astronomers and scientists, and I am now confident that such a society will be formed in the near future.

I next proceeded to Warsaw, where I was the guest of K. Zarankiewicz, president of the Polish Astronautical Society, an IAF member. Here I delivered a lecture on the legal and economic aspects of astronautics before members of the society and their guests, and also discussed plans with leading scientists to organize similar societies in Hungary, Rumania and Bulgaria.

° ° °

I had anticipated going from Warsaw to Moscow but, on learning that my visit would be fruitless because Leonid Sedov had been detained during a trip to Pakistan and Alla Masevich was ill, I abandoned my Moscow trip and proceeded instead to Stockholm.

There, an old friend, Ake Hjertstrand, chairman of the Swedish Interplanetary Society, another IAF member, had arranged a meeting before a group of university air law students. Later, I met informally with the SIS council and, the following evening, with the SIS members.

From Stockholm I flew to Copenhagen, where I was met by my host, Leo Hansen, president of the Danish Interplanetary Society, another IAF member. Here, too, I spoke on the legal and economic aspects of space flight, this time at Copenhagen University. I also had an opportunity to go over IAF matters with members of the Danish society during my stay in Copenhagen.

I spent the next day in Zurich, where I met with Josef Stemmer, IAF secretary and president of the Swiss Astronautical Society, on IAF affairs.

Then back behind the Iron Curtain once more, this time for a trip to Belgrade as the guest of Kosta Sivcev, president of the Yugoslav Astronautical Society, also an IAF member. Here again I found burgeoning interest in astronautics.

My next port of call was Rome, where I arrived a day late for a scheduled lecture before the Italian IAF member group. After a one-day stopover, I proceeded to Palermo, Sicily, for the Third Combustion Colloquium of AGARD.

The meeting ended March 21 and I flew to Paris a few days later for a visit with Gen. Paul Bergeron, president of the French IAF member society, Georges Delval, secretary of the group, and others. I then proceeded to London for a most interesting and productive visit with the L. R. Shepherds, L. J. Carter and their friends of the British Interplanetary Society, and then home.

Throughout the trip, I encountered intense interest in the upcoming IAF Congress in Amsterdam August 25–30.

The extent of world-wide interest in the development of new rocket propulsion methods which will make space travel more practical is indicated by the fact that new astronautical societies have been or are being formed in Canada, India, Colombia, Panama, Ireland, Finland, Turkey, Greece, Belgium, Israel, Rumania, Bulgaria, the Philippines, Australia, New Zealand, Iran, Iraq and Mexico.

Program Set for IAF Amsterdam Meeting

An impressive list of technical papers will be presented at the Ninth Annual Congress of the International Astronautical Federation, to be held in Amsterdam, the Netherlands, August 25–30.

The meeting will open on Monday morning, August 25, with an inaugural lecture by Theodore von Kármán. He will be followed by J. M. J. Kooy of the Netherlands; Eugen Sänger of Germany; and many other renowned scientists. L. R. Shepherd of England will chair the first session.

A partial list of papers and authors follows:

Jakob Ackeret, Switzerland, A System of Plasma Propulsion Using Reactors and Gas Turbines; David Altman, U.S.A., Chemical Propulsion in the New Space Age; G. W. Anthony, Herbert R. Lawrence, Chiao J. Wang, U.S.A., Effect of Gas Dissociation on Rocket Propulsion; W. H. Bostick, U.S.A., Plasma Motors; E. E. Buechner, Germany, Chemistry in the Service of Rocket Technology; Ferdinand Cap, Austria, Astronautics and Relativity, and Prof. W. Gröbner's General and Exact Solution of the Astronomical n-Body Problem and its Application to Astronautics; Sin-I Cheng, U.S.A., The Theory of Meteorite Ablation; and Jean Corbeau, France, Study of Combustion of Drops of Ergol in a Rocket Propellant Combustion Chamber.

Also, Rolf Engel, Italy, Remarks on the Burning Rate of Solid Propellants; Jakob Eugster, Switzerland, Cosmic Rays and Mutations; George Gamow, U.S.A., Astronautics and Astronomy; R. P. Haviland, U.S.A., The Solar Probe; Sam Herrick, U.S.A., Feasibility Orbits vs. Precision Orbits; Rudolph Herrmann, U.S.A., Problems of Hypersonic Flight at the Re-entry of Satellite Vehicles; Joseph Hilsenrath, U.S.A., Thermodynamic Properties of Highly Ionized Gases; H. J. Huth, U.S.A., Electric Power for Space Flight; Joseph Kaplan, U.S.A., Chemistry in the High Atmosphere; J. M. J. Kooy, Netherlands, Wireless Guidance and Control of a Rocket; Bernard Lewis, U.S.A., Space Propulsion by Stardust; and Angelo Miele, U.S.A., General Variational Theory of the Flight Paths of Rocket-Powered Aircraft, Missiles and Satellites.

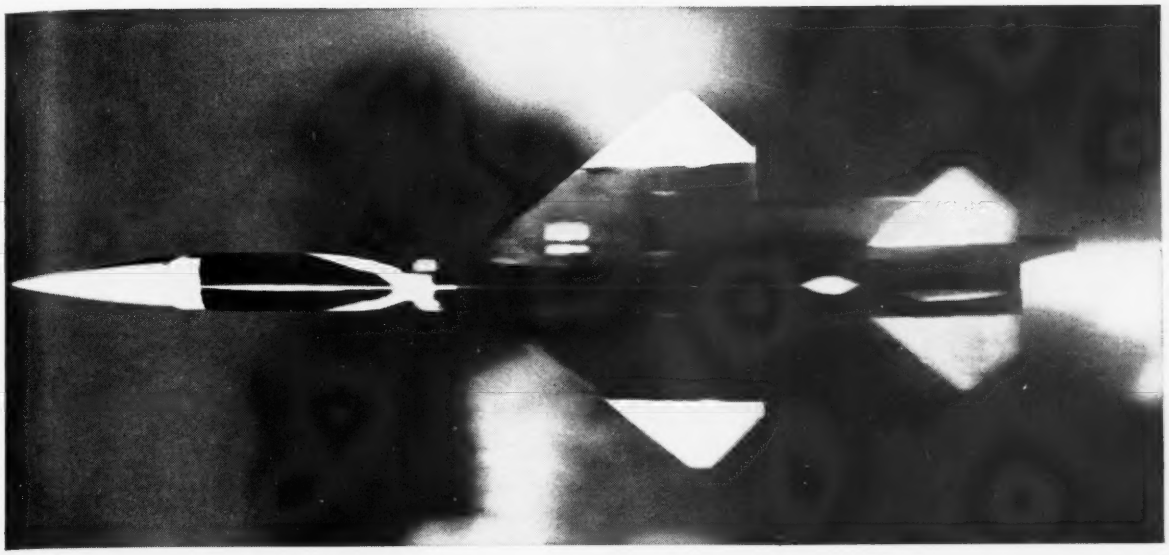
Also, Luigi G. Napolitano, Italy, Magneto Fluid Dynamics of Two Interacting Streams; M. Nicolet, Belgium, Constituents and Composition of the Thermosphere; Konstantin A. Nikitin, U.S.S.R., General Parameters and Characteristics Determining the Effectivity of Fuels for Liquid Propellant Rockets; E. J. Öpik, Ireland, The Meteor Hazard—A Revision; Glauco Partel, Italy, Water as an Oxidant for Rocket Propulsion; Edward W. Price, U.S.A., Oscillatory Combustion Instability in Solid Propellant Rocket Motors; R. E. Roberson, U.S.A., Principles of Inertial Control of Satellite Attitude; Oscar K. Rice, U.S.A., Recombination of Atoms, and Other Energy Exchange Reactions; Eugen Sänger, Germany, Sources of Radiation for Photonic Rockets; Irene Sänger-Bredt, Germany, Working Fluids for Rockets Heated by No Conventional Chemical Energy.

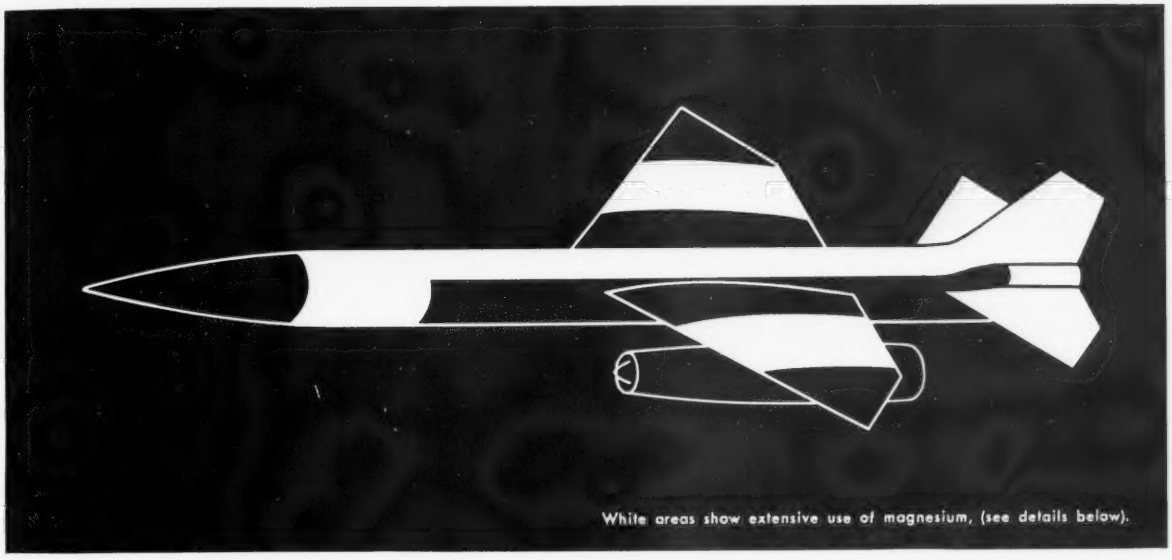
Also, S. F. Singer, U.S.A., Scientific Problems in Cislunar Space and Their Exploration with Rocket Vehicles; Ernst Stuhlinger, U.S.A., Advanced Propulsion Systems for Space Vehicles; Jean Vandenkerckhove, Belgium, The Optimum Design of Solid Propellant Powerplants; Wernher von Braun, U.S.A., Explorer; Theodore von Kármán, U.S.A., Magneto Fluid Dynamics in Relation to Space Flight Problems; T. Winterberg, Germany, Thermodynamics of the Reactors in Nuclear-Energy Rockets; and Olgierd Wolczek, Poland, Nuclear Explosions for the Exploration of Space.

Papers will also be presented by Alla Masevitch and several other Russian scientists at the morning session on Saturday, August 30, and as yet untitled papers will be presented by Dr. Shepherd, E. Vassy of France, Fred Whipple, U.S.A., and several others.

Friday morning, August 29, will be devoted to a colloquium on "The Law of Outer Space," to which more than 25 leading authorities from eight different countries have been invited. Co-chairmen for the session are E. Pépin, Canada; Michel Smirnoff, Yugoslavia; Manfred Lachs, Poland; Robert Homburg, France; and Welf Heinrich, Prince of Hanover, Germany.

On Thursday, August 28, a tour of the Amsterdam area has been arranged for those attending the meeting. —A.G.H.





White areas show extensive use of magnesium, (see details below).

HOW ELEVATED-TEMPERATURE MAGNESIUM ALLOYS HELP BOMARC KEEP FIGHTING WEIGHT

Approximately 230 lbs. of magnesium is used in the airframe of the Bomarc, powerful surface-to-air missile. And for good reason: In each case, the specific application called for light weight and retention of strength, rigidity and other properties at elevated temperatures. The logical choice was sheet, extrusions or castings of elevated-temperature magnesium alloys.

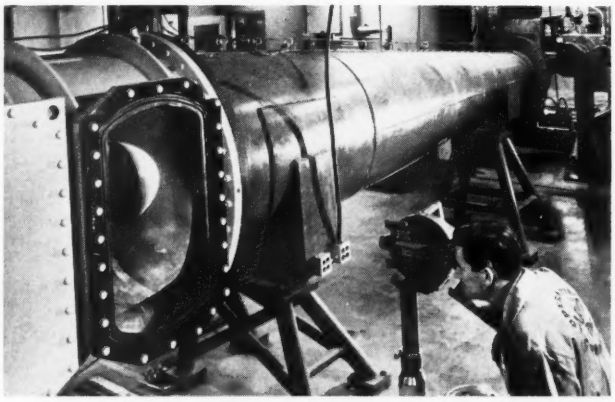
EXAMPLES:

BODY. The body skin and doors of both nose and aft sections utilize 103 lbs. of HK31A sheet and castings. Resultant weight savings were 23 lbs., including a net reduction of 6 lbs. by using a magnesium casting for a door frame structure.

WING, FIN AND TAIL. 111 lbs. of HK31A sheet were used in the wing, elevators and elevator stubs, fin and rudder. All leading and trailing edges of control surfaces for wings and fin are HM31XA extrusions. Here another 8 lbs. were saved by using an elevated-temperature magnesium alloy.

These are but a few instances of how precious weight was saved in the Bomarc. For more information about the use of magnesium alloys in aircraft, rockets and missiles, contact the nearest Dow sales office or write directly to us. THE DOW CHEMICAL COMPANY, Midland, Michigan, Department MA 1407H-1.

YOU CAN DEPEND ON DOW



Hotshot II Wind Tunnel in Action

High-speed camera (left) is trained on theoretical missile nose as electric arc-driven Hotshot II wind tunnel, in which escape velocity has been exceeded, is prepared to fire. Photo at right shows that friction of high velocity air caused incandescence around test object. Piece of torn off nozzle-throat dented nose. The electric arc creates pressures up to 15 tons psi, temperatures to 40,000 F. Runs last about 1/10 sec in the tunnel, part of AF Arnold Engineering Development Center's Gas Dynamic Facility.

Von Kármániana

(CONTINUED FROM PAGE 43)

'They have telephoned from Wright Field that our new airplane has flutter at 450 mph.'

"To which the engineer replied, 'Oh really? I am glad to hear that. In my report to you, I predicted flutter at 445 mph.'" (*Ibid.*, p. 160.)

° ° °

"I once met the famous British aviatrix, Amy Johnson, at a so-called *conversazione* of the Royal Aeronautical Society, where the problem of spin was discussed by British and American engineers and scientists.

"She came to me and asked, 'Can you tell me in a few words what causes spin and what is the mechanism of the thing?'

"Young lady, I told her, a spin is like a love affair. You don't notice how you get into it and it is very hard to get out of." (*Ibid.*, p. 157.)

° ° °

"In 1932, I gave a lecture in Paris on up-to-date problems in aerodynamics and mentioned the wing-fuselage fillet as an effective means of preventing buffeting. It turned out that at that time the French designers had the same trouble we had in the U.S. One of the prominent designers told me later that after my lecture he tried a fillet right away on his new prototype and had success. Thus in France the fillet was connected with my name and was called a 'karman.' The French say an airplane has a 'big karman' or a 'small karman.' I discovered this fact many years later on the occasion of a trip to France. People in aeronautical circles who heard my name asked, 'The man with fillet?'" (*Ibid.*, p. 152.)

° ° °

"A few years ago I was in Paris during the time of the peace negotiations between the Allies and some Eastern European countries. A Hungarian woman journalist came to me and wanted an interview. She asked me what I thought was the greatest progress in aviation in the last decade. I told her, propulsion by reaction.

"She said to me, 'Professor, could you express this in some other way? I cannot write in a progressive paper that progress is accomplished by reaction.'" (*Ibid.*, p. 166.)

° ° °

A few of von Kármán's favorite stories:

"I am often impressed by the ingenuity of advertising men. I remember seeing a sign in Paris reading 'Yankee, Go Home.' After it someone had written 'By Pan American.'" (Told to Lee Edson)

° ° °

At the Farnborough Air Show, von Kármán met Jack Profumo, who introduced himself as the Parliamentary Secretary of the British Ministry of Defense advising the Royal Aircraft Establishment on policy. "Oh," von Kármán said, "that reminds me of the centipede who had gout. This, as you can well imagine, was quite unbearable, so he went to the wise owl to seek advice.

"The owl considered the problem and said: 'This is really quite simple. All you have to do is transform yourself into an animal with fewer legs—a mouse, for example.'

"The centipede thanked the owl profusely and was about to leave when a thought struck him. 'How in the world,' he asked, 'can I get myself transformed into a mouse?'

"The owl puffed himself up and fastened a stern eye on his questioner. 'How should I know?' he replied, 'I only advise on policy.'"

° ° °

Finally, here are some stories told about the good doctor:

Von Kármán's dislike of stuffiness is well known. An oft-told story concerns the time a famous scientist from

Boston visited his laboratory at Cal Tech. Von Kármán showed him around and introduced him to his colleagues, some of whom came from such far-off places as China, India and Hungary.

"How come you employ so many foreigners?" the proper Bostonian inquired.

Von Kármán looked at him indignantly. "What should I do then?" he demanded. "Hire a Navajo Indian?"

* * *

Von Kármán drives a 1939 sedan. Once asked why he doesn't buy a new car, he replied: "I never interfere with my old habits."

* * *

In 1952, at the Fourth International Symposium on Combustion at MIT, von Kármán participated in a round-table discussion of various combustion theories. One scientist claimed he had a theory which would give correct results, only he needed accurate data on all the transport phenomena occurring during the process.

Von Kármán promptly recalled an experience of his student days at Göttingen, when he had a friend who was obsessed with the notion of building a perpetual motion machine and was actually working on his idea. One morning he met von Kármán and excitedly exclaimed: "I've got it! I've really got it now! There is only one more thing I need. A very small thing which will do this." Whereupon he raised his little finger and crooked it back and forth.

* * *

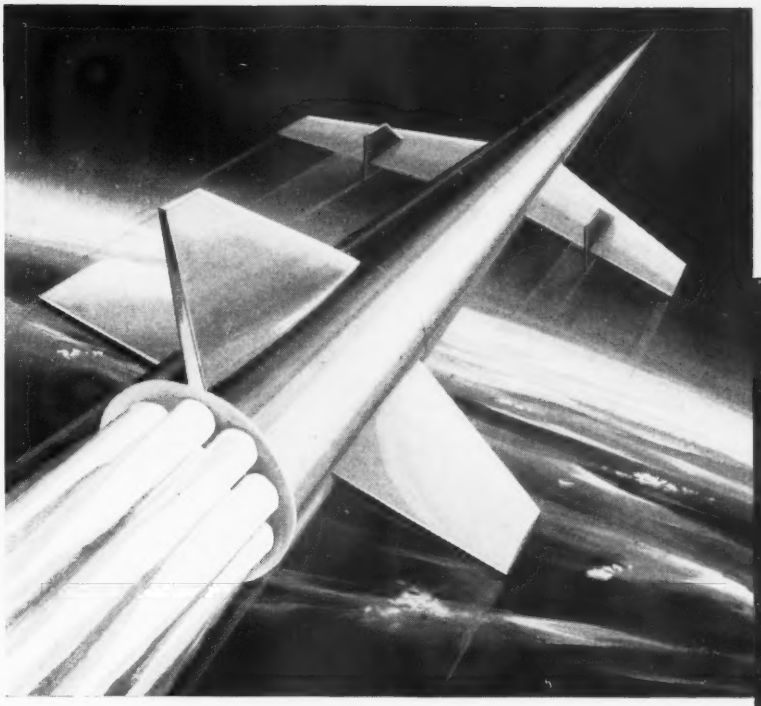
At the same meeting, a controversy arose between two groups which held to different theories concerning the explanation of a certain phenomenon. In either case, however, the experimental results still differed from those expected from theory by a few hundred per cent.

This recalled to von Kármán the story of the two GI's touring Rome after the war. At the Coliseum, one of the GI's remarked indignantly: "What vandals the Germans were."

The other GI protested. "That wasn't the result of German bombing. These ruins were made earlier by our own Air Force."

An argument arose, followed by a bet. To settle it the GI's consulted a passerby. "I don't know exactly when the Coliseum was destroyed," the passerby said, "but it must certainly have been more than 1000 years ago."

The soldier who'd blamed the Americans turned triumphantly to his partner. "See," he said. "I win. I was closer."



Engineers—Scientists

The Bell Aircraft *Rockets Division* forges ahead with new types of rocket engines and propellents to provide the higher thrust and greater efficiency needed to push missiles, satellites and manned space vehicles through the earth's atmosphere into outer space.

These programs are the outgrowth of over a decade of Bell experience in rocketry, beginning with the record-breaking X-1 and X-2 supersonic rocket-powered aircraft, and continuing with the development of rocket power plants for projects like the Rascal air-to-surface missile.

Continued growth and expansion in the *Rockets Division* have opened a number of select positions in the following fields:

Propulsion Systems Development
Combustion and Fuels Research
Systems Installation
Structural Analysis
Instrumentation
Rotating Machinery
Controls Development
Laboratory Testing

To learn more about the personal opportunities and unexcelled benefits now available to you as a member of our Rockets Division engineering team, send resume of your qualifications to: Supervisor of Engineering Employment, Dept. Y-30, Bell Aircraft Corporation, P.O. Box One, Buffalo 5, New York.

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from the patent office

BY GEORGE F. McLAUGHLIN

Compressed Fuel Increases Engine Thermal Efficiency

Improved efficiency from a jet-propelled duct is claimed for an invention featuring a system for compressing the fuel mixture by a preliminary explosion just before the main fuel ignites. Firing the mixture in this manner converts a greater proportion of available energy from the fuel into useful work.

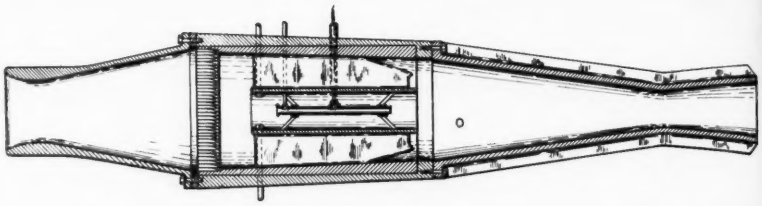
Precompression of the main fuel charge is achieved by exploding in the region of the main fuel mixture a preliminary charge which pressurizes the regular fuel mixture. The effect is produced by exploding the preliminary charge in a tube within a combustion chamber in which the regular charge is to be burned. The initial charge can be one which burns at a lower temperature or pressure or both than the regular charge, and the increased temperature or pressure caused by the explosion can be used to ignite the regular charge.

Firing the preliminary charge subjects the main charge to pressure from both ends of the main firing chamber. The initial explosion may also be created by using substances which spontaneously explode upon contact with air, or, which may be catalytically exploded in air—a "cascading" type of explosion.

A duct leading into a tube within the firing chamber admits a mixture which is more easily ignited or oxidized than the main fuel charge.

The device comprises a shell forming a duct through which air flows. The leading section of the shell is circular for one-third of its length from the entrance, and then undergoes a transition to correspond to the rectangular outline of the center section. A square spacer frame fits between the sections. The center section tapers from the front to a point beyond the center, where it begins a transition from rectangular to circular to correspond to the front of the tail section. The tail continues to taper toward the rear up to a point about two-thirds its length, where it enlarges as it approaches the nozzle opening. The tail section has longitudinal radiation fins for cooling.

A valve to control fluid flow through the duct is located near the forward end of the channel, and divides the duct into forward and rear parts. The valve is built up with flexible blades alternately interleaved between rigid channels, held near their leading edges between the strips of one channel and the front flat face of the next. These valves and channels occupy the space ahead of the firing chamber.



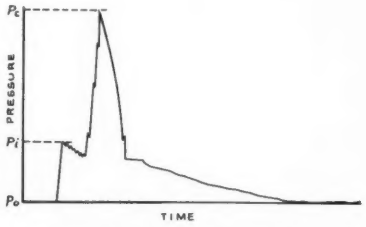
Longitudinal cross section of jet motor having small diameter centrally located firing tube from which explosions ignite main charges in the combustion chamber.

A combustion chamber within the shell is held by vanes attached to the rectangularly shaped insert section and to the chamber. Fuel injectors are provided in the cylindrical chamber.

Supporting legs hold the firing tube in position within the chamber. A fuel injector is located near the forward end of the tube. The tube is shorter than the chamber, providing a region at either end where the effects of the explosion within the tube act upon the charge in the chamber.

Fuel under pressure is introduced into the chamber through injectors. A more reactive or explosive material is introduced through the injector and fired in the tube.

The apparatus operates as follows: The tube is charged with a fuel more easily explodable than that supplied to the chamber. For example, if the fuel supplied to the chamber is gasoline, fuel supplied to the tube may be oxygen and hydrogen, propane, butane, pentane, etc. The more stable fuel is supplied to the chamber simultaneously with the fuel supplied to the firing tube. The charge in the tube is detonated and the explosion creates pressure regions at both ends of the chamber. This puts the charge under pressure. When the charge has been compressed a sufficient degree and the temperature has risen to the proper point, the charge in the chamber will explode.



Graph showing the relative effect obtained by cascading action as compared to single explosion operation.

The force of the explosion causes the valve to shut off the flow of air entering through the mouth and permits combustion products to escape out of both ends of the chamber. Part of the combustion products pass toward the rear, and the remainder issue from the front of the chamber and then escape toward the rear through the outer duct. When the pressure generated by the explosion diminishes to the point where it is exceeded by the pressure acting on the forward side of the valve, the valve again opens and permits a free flow of air through the duct.

When the valve opens to permit scavenging of the products of the first explosion, a new charge of fuel is admitted into the chamber, and a new charge introduced into the tube. The smaller charge is exploded and the entire combustion process repeated. The operation consists of a series of these double explosions rapidly following each other, so that substantially continuous thrust is produced.

The effect of the explosion in the tube upon the power to be derived from the ultimate explosion in the chamber is illustrated in the accompanying graph, in which the pressure developed by cascading explosions is compared to the effect of a single explosion. Pressure reached at the end of initial detonation is shown by Pi, and the resulting pressure developed after the explosion of the second detonation is shown by Pc. The graph taken during operation of the device shows the gain in pressure and work obtained by use of the invention.

Patent No. 2,821,838. Jet propulsion device for operation through fluid medium and method of operating it. Fritz Zwicky, Pasadena, Calif., assignor to Aerojet-General Corp.

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Scoring Systems

(CONTINUED FROM PAGE 37)

analyzer is also an airborne component. The in-flight monitor receives information varying with the particular missile characteristics—that is, if the missile is active, semi-active, pure seeker or ballistic. Some tactical missions require in-flight data from the target when other data are not available. The target provides data to the in-flight monitor on elusive maneuvers or for the activation of countermeasures.

The evaluation indicator and recorder can transmit information to the aircraft and show on a pilot indicator a digested evaluation and kill data for rapid disclosure of pilot error or system malfunction before the pilot makes a second pass. The information disclosed by the evaluation indicator depends on the kill detector to give the results of the mission, and on the prelaunch and in-flight data to show why those results were obtained. The form of the data from the kill detector is very important in making the evaluation.

Depending upon the kill detector, weapon system evaluation is based on the following definitions:

Proximity scoring—This system indicates the entrance of a projectile within a given boundary sphere of radius, R, about the target. In proximity scoring, no distance or coordinate values are known. In the drawing on page 37, if $\vec{m} \leqq R$, a hit is registered. This is a "go-no go" system.

Miss-distance scoring—The minimum distance at which a projectile passes the target is the perpendicular distance from the projectile trajectory to the target. This system determines the distance $\vec{m}$ although no coordinate values are known.

Planar Scoring—This system indicates the distance and coordinates of the entry point of the projectile through a plane passing through the target. These are shown as the vectors $\vec{m_0}$ and $\vec{m_2}$ in the drawing.

Spherical Scoring—Sometimes called "burst distance," this system indicates the miss-distance point, its coordinates, and the missile trajectory. This is shown as $\vec{m}$ in the drawing.

Some scoring system limitations or associated problems are as follows:

Zone, or "go-no go": Control of zone diameter to make it sharp is difficult for all approaches. This is a very useful system for fully developed weapons having a high kill radius, but is not useful in determining malfunctions. Miss Distance: Limited to dummy-warhead missiles where the projectile actually passes the target. Spherical Scoring: Trajectory measurements are subject to error caused by target maneuvering or motion of the reference axis defined by the target. Burst-Distance Indicator: Scoring data are usually incomplete. Difficulties encountered here actually apply to any of the above systems which have an active warhead bursting as the missile approaches its target.

The lack of a good kill detector deters progress in integrated scoring systems. Engineers have reached into every chapter of their physics texts for means to develop kill detectors, and probably never before has an engineering problem been approached with such diversity without reaching a higher degree of success.

There are probably over 50 differently sponsored scoring systems, half of them with different approaches. Most fall into one or more of these basic approaches: Infrared, electronic, light, optical-photographic, acoustic, radioactive, electrostatic, magnetic, or hole counting.

Some limitations of these approaches are as follows:

Hole Counting: Limited to small armaments; data reduction delayed. Magnetic: Susceptible to errors from closure rate and projectile spin velocity. Electrostatic: Limited range. Radioactive: Special handling problems. Acoustic: Limited to subsonic targets. Optical: Limited to clear weather and special light conditions. Electronic: In uncooperative systems, limited to large missiles (large reflection area). Cooperative systems usually require dummy warheads or some adjustment to the missile. Thermal infrared: Limited by weather and cloud conditions; sometimes affected by the sun; require scanning systems.

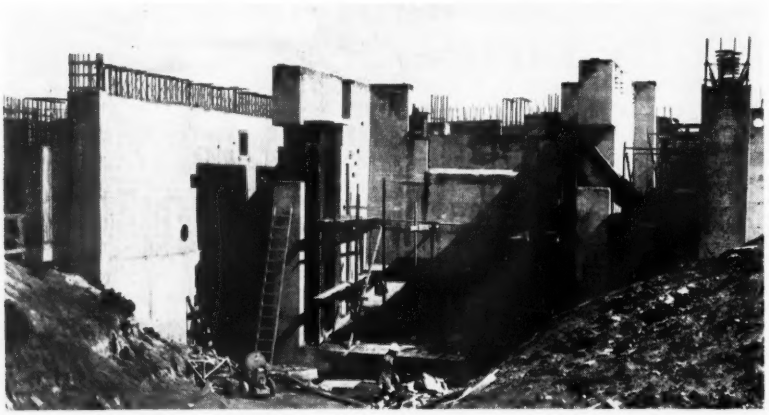
In most cases, the kill detector is located in the target, with, possibly, some cooperative device in the missile. This is not the only approach, however, since some systems have the main portion of the system on the ground. Such a system may be either cooperative or noncooperative with respect to the missile and target. The track of each is maintained by the ground station, providing spherical scoring information.

Some kill detector approaches to avoid include:

1. Triangulation from the target—Limited to very small scoring ranges for small targets.
2. Scanning Systems—Limited to slow missiles or projectiles.
3. Pulsed Radar—Limited to large scoring ranges.
4. Systems that cannot provide real time data.
5. Systems that do not permit rapid data reduction.
6. Systems that cannot have in-flight calibration.
7. Cooperative systems, because of missile maintenance problems.

Since the heart of an integrated scoring system is the kill detector, it is not surprising that much attention today is being given to its development. However, a kill detector alone is of limited value, since the goal is not only to record a hit or miss, but also to provide a guide for development and improvement of the weapon system. A complete integrated scoring system of the type described here can be of inestimable value in collecting this information.

Based on a paper presented at the ASME-ARS Aviation Conference in Dallas, Tex., March 17-20, 1958.



ICBM Launching Site

This is one of the three ICBM launching sites being built at Cooke AFB, Calif. Upon completion next fall, SAC's 1st Missile Div. will move in to train missile crews.

Teal Motor

(CONTINUED FROM PAGE 33)

is a subsonic type with a mild-steel nozzle insert at the tip. The nozzle insert press fits into the blast-tube insulation. A thin copper disk on the downstream side of the nozzle insert aids ignition by allowing some motor pressure buildup, and also serves as a moisture seal. The motor assembly is shipped with a thrust-neutralizing plug in place of the blast tube, which is installed in the field.

Fore and aft flanges of the motor assembly are machined and drilled for attaching nose and tail sections of the drone. The forward closure ring and the three reinforcing rings are drilled along the lower half of the case to accommodate the 17 electrical control wires, which terminate in Bendix-Scintilla connectors.

The desired sustain-thrust duration and the available motor space dictated the use of an end-burning, cylindrical propellant charge. While it was possible to provide a short boost phase by any of several charge designs, a brief development program led to the selection of a disk of propellant bonded to the aft end of the sustain grain as the simplest workable system.

Used in Other Applications

Both grains are extruded from composite propellants containing approximately 80 per cent ammonium nitrate as the oxidizer, 10 per cent synthetic rubber as the fuel-binder, and 10 per cent of other ingredients, such as burning-rate catalysts, plasticizers, carbon blacks and curatives. A higher burning rate for the boost-phase propellant is obtained by modifying the catalyst system and using slightly different propellant-processing techniques. Both propellants have been used extensively by Phillips in other applications; the sustain-phase propellant is the standard M15 JATO propellant.

The propellant ingredients are mixed in a Baker Perkins mixer equipped with dispersion-type blades. Mixing conditions are controlled rigidly to produce propellants with the desired physical and ballistic properties. A large hydraulic press extrudes the mixed propellant as solid cylindrical grains of the desired diameter, which are then cut to length.

Inhibiting, or restriction, of the periphery and forward end of the grain is necessary to limit burning to the aft-end surface and to maintain a neutral thrust characteristic. Temperature cycling and thermal effects of the extremely long motor burning time impose severe conditions on the inhibitor.

Various materials and methods of application were tried before an acceptable inhibiting system was found. Selected as an inhibitor was a GR-S rubber compounded with carbon black, plasticizers and curing agents. After compounding, the material is mill-rolled into sheets approximately 0.15 in. thick.

The boost and sustain grains, cut to length, are bonded together by a thin film of polyurethane cement. A sheet of GR-S inhibitor is bonded between an aluminum forward end plate and the forward end of the dual grain, and the GR-S inhibiting sheet is wrapped around this assembly. The assembly is then placed in a curing device, which applies pressure while it oven-cures for 24 hours at 190 F. This vulcanizes the grain to the inhibitor.

When cool, the assembly is removed from the curing device and is spirally wrapped with pressure-sensitive aluminum tape. This tape adds strength to the inhibitor and serves also as insulation.

When loaded into the insulated motor case, the charge is supported

If you want

Accuracy •
Vibration Resistance •
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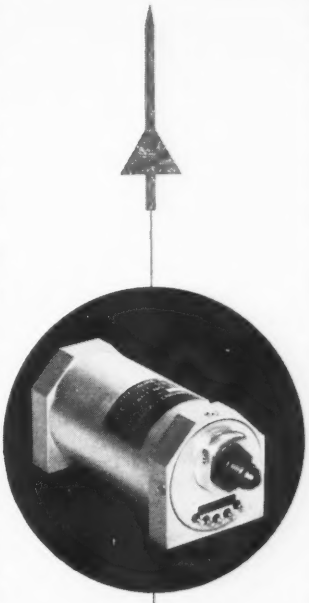
High Output •
Small Size •

in a pressure pickup for flight control or guidance applications then you want



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Vibration: 25 g, up to 2000 cps
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Phone: ELgin 5-7186

by a cap screw, which threads into the forward end plate through an opening in the forward head. The inhibitor gives lateral support to the aft end of the charge. The charge is trimmed to fit closely to the insulation. A sponge-rubber ring between the forward end plate and forward head assists in dampening shock and somewhat reduces free volume in the case.

A one-piece, 0.6-in. wall tube of reinforced plastic press fits into the blast tube and insulates it. The steel nozzle insert press fits into this insulation. The insulation is thus reduced at the nozzle, and the highest temperatures on the blast tube occur there.

The aft end of the case and the straight section about 10 in. forward of the aft head are insulated by a reinforced plastic liner, which is cemented in place. Thickness of the straight section is $^3/_8$ in. A laminated structure about $^1/_4$ in. thick insulates the shell forward of the plastic liner. This structure consists of reinforced plastic and ceramic materials, which form a very efficient, lightweight insulation. Inhibitor in this area is built up to reduce free volume in the motor.

Pyrotechnic Igniter Used

A pyrotechnic igniter starts the motor. The igniter is built-up on a $1^3/_4$-in. diam. steel body which threads into the aft head. An asbestos-phenolic material insulates the steel body. A wire basket, mounted on top of this insulation, holds squibs and pyrotechnics. Two insulated squib-contact posts extend through the steel body and insulation. Suitable wires and a Bendix-Scintilla plug and shorting receptacle serve as the external igniter circuit.

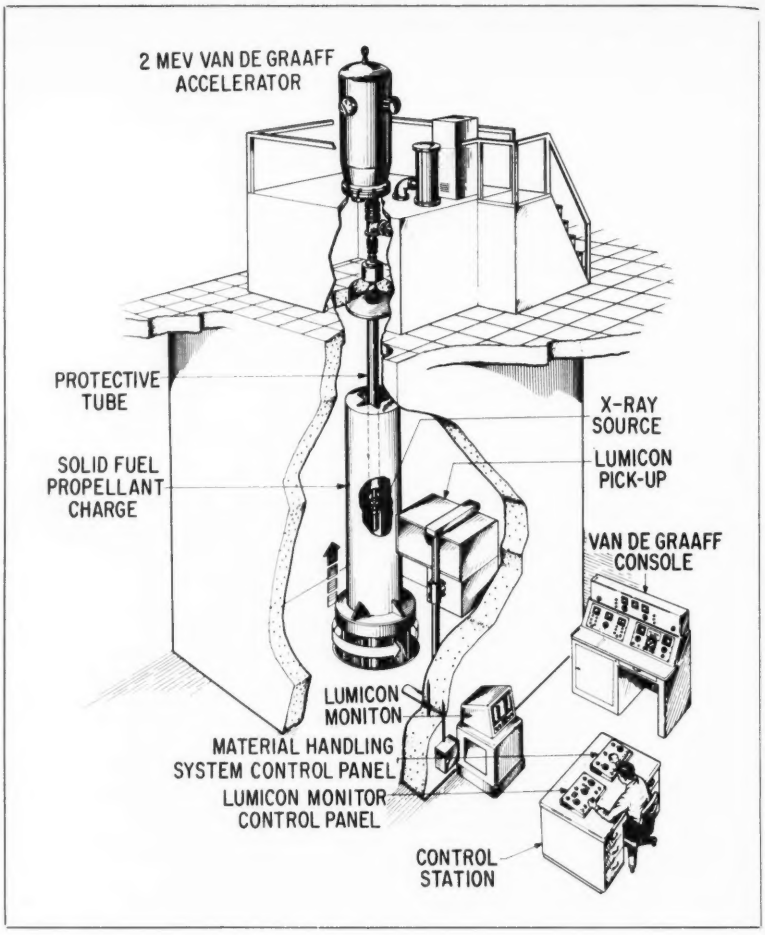
Two DuPont S-89 squibs, wired in parallel to the contact posts, serve as the internal circuit. Six grams of granular pyrotechnic in a small polyethylene bag surround the squibs. The wire basket contains 30 gm of pelleted pyrotechnic (metal powder as fuel and potassium perchlorate as oxidizer). The wire basket is coated with Tenite and a rubber solution.

Thirty-five motors were subjected to acceptance tests, which included vibration, temperature cycling between 20 and 100 F, temperature cycling between 20 and 100 F plus final conditioning at −75 F for four hours before firing, altitude cycling, drop testing and statistical firings. Results of these evaluation tests were satisfactory, and the motor was accepted by Navy BuOrd for flight testing.

Because the electrical wiring and instrumentation are near the motor, the external temperature of the motor shell must be lower than that required to maintain adequate motor-case strength. The case forward of the aft reinforcing ring remained below 300 F. The highest case temperature appeared at the top and just forward of the aft head. This area, of approximately 4 in. diam, reached 700 to 800 F at the end of firing. The remainder of the case in this area, including the aft head, remained under 375 F. Blast-tube temperatures were under 450 F, except for the very aft end, which reached a maximum temperature of 550 F. Flight tests showed that motor and blast-tube temperatures are acceptable.

Average internal-ballistic values for an initial motor temperature for 60 F from the evaluation test are given on page 33, together with typical thrust

New Method for Spotting Flaws in Solid Propellants



A new technique of inspecting solid propellant and missile fuel charges by lowering a powerful radiographic generating unit into the hollow core has been jointly developed by High Voltage Engineering, Thiokol Chemical and the Friez Instrument Div. of Bendix Aviation. The unit is said to cut penetration requirements by 50 per cent.

The heart of the system is a Van de Graaff X-ray particle accelerator with a special 10-ft electron tube extension that slips down into the propellant core and generates high energy X-rays from the tip of the tube. As shown in the illustration, the fuel charge, placed on a base, is rotated and raised spirally about the X-ray source. A continuous radiographic picture covering the entire volume of the fuel charge is monitored on the Lumicon receiver outside.

Heretofore, inspection has been a costly, cumbersome process of wrapping radiographic film around the outer surface of the missile or arranged in a flat plane.

and pressure-time curves for a 60 F static firing. Thrust values are for sea level.

Ignition delay for the motor is approximately 1 sec. Because of the slow pressure buildup in the engine and the relatively small amount of igniter pyrotechnic, igniter shock is almost nonexistent. Ignition reliability has been good in both static and flight tests.

Since completion of this evaluation, Temco and the Navy have conducted flight tests of Teal at the U. S. Naval Air Missile Test Center, Point Mugu, Calif. Performance and reliability of the motor during these tests have been satisfactory. Teal was launched from the F3H Demon fighter.

The successful development of this motor has proven the feasibility of long-duration, solid-propellant rocket engines.

Based on a paper presented at ASME-ARS Aviation Conference in Dallas, Tex., March 17–20, 1958.

Hellenic Astronautical Society

Formation of the Hellenic Astronautical Society, with headquarters in Athens, has been announced. Stavros Plakidis, professor of astronomy, National University of Athens and director of Athens National Observatory, is president, and Elie Petropoulous is secretary-general.

Electronics Conference To Be Held Aug. 13-15

A Conference on Electronic Standards and Measurements jointy sponsored by the American Institute of Electrical Engineers, Institute of Radio Engineers and the National Bureau of Standards, will be held at the NBS Boulder Laboratories, Boulder, Colo., Aug. 13–15.

MIT Summer Program

MIT will present lectures and laboratory demonstrations on new developments in the fields of aeroelasticity and structural dynamics during a special summer program, June 23–July 3. Emphasis will be on guided missiles and supersonic and hypersonic aircraft. Tuition for the program, offering no academic credit, will be $250.

RMI, Thiokol OK Merger

Stockholders of Reaction Motors and Thiokol Chemical Co. have formally approved the merger of the two companies into Thiokol Chemical. RMI stockholders will receive one share of Thiokol for each $1^1/_4$ shares of RMI stock held.

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TRANS-SONICS

Precision Transducers

National Design Award

Ryan Aeronautical Co. won a $500 first prize and plaque in a nationwide product design competition for best use of materials with its MiniWate combination of corrugated and flat, extremely thin steel adaptable for use in supersonic missiles and aircraft and space vehicles.

Simulation Techniques

(CONTINUED FROM PAGE 35)

tuning a fine one; and, after both adjustments have been made, the bandwidth of the tube itself is perhaps 10 mc. It is important to realize that either mechanical or electronic tuning is a physical operation that must be performed by someone or something, and, at very best, any tuning must necessarily be less than perfect—where "perfect" is taken to mean here "instantaneous."

The traveling-wave tube, which originated shortly after World War II, is vastly superior to the klystron as a microwave electronic amplifier. It can increase power in simulated radar reflection by a factor 100 to 1000 times greater than a klystron, and is inherently wideband in operation. For example, a single tube covers the entire frequency range from 8000 to 12,000 mc without tuning.

The importance of tuning cannot be exaggerated. If the drone is to operate as a radar target against only one radar, whose frequency is fixed and known in advance, then a klystron can be tuned and set to that one particular radar frequency prior to flight. The power gain of the simulated radar reflection from the klystron amplifier would again be only 1 to 0.1 per cent of that produced by a traveling-wave tube amplifier in the same situation.

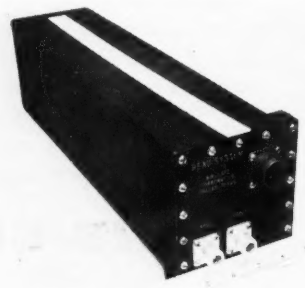
In the more general situation, however, where it is necessary that the drone simulate a radar target to several different radars, each operating on different frequencies—radars in the air, on the ground or both simultaneously—the klystron could simulate a radar target to only one of the several radars, for the simple reason that the inherent frequency bandwidth of this tube is about the same as the bandwidth of any one of the radars. If the radars are to avoid interferences between themselves, they must be tuned further apart than the inherent bandwidth of the klystron.

On the other hand, the traveling-wave tube can realistically simulate a radar target to *several radars simultaneously* because of its enormous inherent frequency bandwidth. And, again, only one adjustment to the traveling-wave tube amplifier is necessary—again control before flight. Finally, the time delay of the traveling-wave tube is only about 0.1 microsec (10^{-7} sec), corresponding to a radar error of less than 50 ft at worst.

Aside from the subject of microwave electronic amplifiers, it should be stated parenthetically that narrow bandwidth restrictions for a single radar, time delays which are much too large, and the unreal variation of simulated radar target size with changes in range, are important reasons for *not* using the familiar "Identification of Friend or Foe" (IFF) beacon-transponder to make a small target appear to a radar to be a realistic large airplane.

Because of the tremendous advantages of the traveling-wave tube, the author is presently involved in the development of a traveling-wave tube amplifier for target drones called the Radar Echo Augmentation Device (READ). One version has been flight-tested against several kinds of X-band (8500 to 10,000 mc) radars, both airborne and ground-based, in several locations in the U.S. The airplane carrying the READ was a small, light vehicle, but it gave the appearance of a Douglas DC-7 or Lockheed Constellation on both PPI-scopes (the "picture-tube") and A-scopes.

Patent is pending on the device, listing the author as inventor; and a commercial unit for X-band echo augmentation has just been released, as shown here without antennas, which are tailored to the carrying vehicle. This unit, a hermetically sealed case containing the traveling-wave-tube amplifier and associated transistorized power supply, weighs less than 10 lb and has an operating life of at least 400 hr. The unit requires 80 watts of input at 24–29 v d.c.



Commercial X-band READ.

This version of READ should be capable of being installed in nearly all kinds of target drones built to date and also in most future drones. The READ system could also be used commercially in small planes for Ground Controlled Approach (GCA) landings and to warn large planes equipped with search radar of the presence of these small planes. Models of READ for S-, L-, and C-band augmentation are under development.

Infrared Simulation

Infrared (IR) radiation propagates analogously to radar. However in radar simulation, it is the radar reflection from the target which is simulated, not direct radiation from the radar itself. A relative disadvantage of infrared simulation is that the direct radiation from the infrared source itself (jet or rocket engine) must be simulated, and not reflections from the target.

The physical difference between radar and IR simulation is clear. Radiation propagates outward from a radar transmitter as a spherical wavefront with the velocity of light, and the target intercepts and reflects only a very small portion of this wavefront. Thus it is possible to simulate characteristically small radar reflection with a small amplifier. The only way to simulate a particular IR source, however, is with another source that delivers the same power over the same band of wave lengths. It is *power* that is simulated, whether for radar or IR.

The power of an IR-simulation emitter should equal the power of the source simulated. A small IR simulator must consequently have very high temperature. A practical consequence is that IR simulation of large, hot, jet engines and even hotter rocket engines can be accomplished by small flares on target drones only for short periods of time. Infrared simulation for drones presently is limited to the use of small, hot flares burning for a few minutes. These flares augment radiation from the jet or rocket engine on the drone to simulate a single, larger source.

Based on a paper presented at the ASME-ARS Joint Aviation Conference in Dallas, Tex., March 17-20, 1958.

Guiding a missile, or speeding flight and flight environmental data back to control and tracking centers, is too much of a job for conventional communication systems. Supersonic speeds call for lightning fast data communications, coupled with the utmost reliability.

Capitalizing on the ease of converting messages into digital form, Motorola scientists and engineers have developed a number of Data Link Communications Systems suitable for piloted aircraft, as well as missiles.

NERVE CENTER FOR DATA LINK SYSTEMS

With Data Link Systems, messages that have been translated into on-off pulses can be transmitted by any of the common modulation schemes with a suitable carrier. The transmitter can be air-borne, ship-borne, or land-based. Received messages are amplified, decoded, and transformed into a form suitable for display, or stored for some future time, or used for direct control through auto pilots, for example.

One of the Data Link Systems designed at Motorola utilizes an all-transistor converter-coupler, packaged in modular form. The total system consists of eight modules, each approximately 4" x 8" x 1½". The fully transistorized circuitry is of the highly reliable diode-matrix type logical circuitry used in many digital computers. The switch type transistors employed are a product of the Motorola Semi-Conductor Division. Indicative of the stringent testing program to which the transistors are subjected is a 1000-hour life test at 85° C.

For another Data Link program, Motorola has designed a system featuring resolver-type outputs. A single time-shared servo amplifier positions anyone of the five resolvers in accordance with commands from the ground transmitter.

These two Motorola Data Link Systems aimed at solving one of the important communication problems of the missile age are examples of the complex programs conducted by Motorola for varied military needs.

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government contract awards

Titan Equipment Contract

A supplementary $3 million contract for instrumentation and field test equipment for the AF Titan has been awarded to Hallamore Electronics by The Martin Co.

Sidewinder Components

Bausch & Lomb Optical Co. has been awarded a subcontract by Philco Corp. to provide major optical components for the Sidewinder missile.

B-58 Defense System Award

AF has awarded an additional $23 million contract to Sylvania Electric Products for expanded production of the electronic countermeasures system —automatic defense system—for the B-58 Hustler.

Aerojet Gets Development Job

Aerojet-General's Solid Rocket Plant at Sacramento has received a $1.5 million AF contract for solid propellant rocket development.

Plato Award to Sylvania

The Army has awarded Sylvania Electric Products an additional $4.5 million contract for expanded development of the Plato anti-missile system for the field armies.

AF Tall Tom Project

Olympic Radio & Television Div. has been awarded an Air Force $700,000 contract for the development of airborne and ground recording and data handling equipment for the Tall Tom all-electronic reconnaissance system.

Army Data Center

Data-Control Systems, Inc., has received an Army contract for construction of a major data center for use in Army missile and satellite research programs.

Data Reduction Services

Telecomputing Corp. has received a $636,000 additional Army contract for data reduction services at White Sands Proving Grounds, Alamogordo, N.M.

Subminiature Gyro Compass

American Bosch Arma Corp. has licensed S. G. Brown, Ltd., Watford, England, manufacturer of gyroscopic equipment, to manufacture and sell the Arma subminiature gyro compass.

Mobile Command Post

Aeronutronic Systems, Inc., has been awarded a $6,851,000 Army contract for development of a mobile automated command post.

SYNOPSIS OF AWARDS

The following synopsis of government contract awards lists formerly advertised and negotiated unclassified contracts in excess of $25,000 for each Air Force, Army and Navy contracting office:

AIR FORCE

AF Missile Development Center, ARDC, USAF, Holloman AFB, N. M.

Liquid propellant rocket sled system, $447,000, **North American Aviation,** Rocketdyne Div., Canoga Park, Calif.

Thrust units, $634,926, **Grand Central Rocket Co.,** P.O. Box 111, Redlands, Calif.

Modification of liquid-propellant sled and fabrication of a forward vehicle, $89,066, **Coleman Engineering Co., Inc.,** 3500 W. Torrance Blvd., Torrance, Calif.

AF Missile Test Center, ARDC, USAF, Patrick AFB, Fla.

Rocket propellant, $37,873, **Westvaco Chlor-Alkali Div.,** Food Machinery & Chemical Corp., 161 E. 42 St., N.Y.C.

Comdr., Hq. AMC, Wright-Patterson AFB, Ohio.

F-100D cockpit procedure trainers, $407,006, **Reflectone Corp.,** Post Rd., Stamford, Conn.

Product improvement for Q-2 drone system, $1,387,293, **Ryan Aeronautical Co.,** San Diego, Calif.

Aerial target drones, $690,000, **Radioplane,** A Division of Northrop Aircraft, Inc., 8000 Woodley Ave., Van Nuys, Calif.

Product improvement M-16 rocket engine in support of Matador missile, $597,145, **Thiokol Chemical Corp.,** Utah Div., Brigham City, Utah.

TM-76A missile, data and spares, $10,192,000, **The Martin Co.,** Baltimore, Md.

Hq. AF Flight Test Center, ARDC, USAF, Edwards AFB, Calif.

Viper II rocket engines, $159,781, **Grand Central Rocket Co.,** P.O. Box 111, Redlands, Calif.

Hq. AF Office of Scientific Research, ARDC, Washington 25, D.C.

Research on the influence of ions on rocket combustion, $44,332, **Reaction Motors, Inc.,** Denville, N.J.

Study of the acceleration and channeling of plasma jets by magnetic fields, $98,450, **Giannini Research Laboratory,** 18400 S. Main St., Santa Ana, Calif.

An investigation of the high intensity arc for ion propulsion, $65,000, **Vitro Laboratories,** Div. of Vitro Corp. of America, 200 Pleasant Valley Way, W. Orange, N.J.

Analytical studies on ion propulsion, $90,438, **North American Aviation, Inc.,** Rocketdyne Div., 6633 Canoga Ave., Canoga Park, Calif.

Hq. Ogden Air Materiel Area, USAF, Hill AFB, Utah.

Spare parts for F89 aircraft, $152,369, **Northrop Aircraft, Inc.,** Northrop Div., Hawthorne, Calif.

Kits for F101 aircraft, $146,050, **McDonnell Aircraft Corp.,** Box 516, Municipal Airport, St. Louis 3, Mo.

Spare parts for F89 aircraft, $55,773, **Northrop Aircraft, Inc.,** Northrop Div., Hawthorne, Calif.

ARMY

Boston Ordnance Dist., Army Base, Boston 10, Mass.

Complete area toxic rocket weapons systems, $101,230, **Arthur D. Little, Inc.,** 35 Acorn St., Cambridge, Mass.

Data acquisition system for structural testing of guided missiles, $118,230, **Epsco Inc.,** 588 Commonwealth Ave., Boston 15, Mass.

Los Angeles Ordnance Dist., U.S. Army, 55 S. Grand Ave., Pasadena, Calif.

Furnishing and delivering of depot replenishment repair parts for the Corporal missile, $380,576, **Gilfillan Bros. Inc.,** 1815 Venice Blvd., Los Angeles, Calif.

Replenishment repair parts for guided missile, artillery M2, and related ground handling equipment, $86,931, **Firestone Tire & Rubber Co.,** 2525 Firestone Blvd., Los Angeles 54, Calif.

Study reports for drop test of Jupiter nose cone, $494,000, **Aerophysics Development Corp.,** P.O. Box 689, Santa Barbara, Calif.

Honest John improvement program, $294,521, **Douglas Aircraft Co., Inc.,** 3000 Ocean Park Blvd., Santa Monica, Calif.

Spare parts for Corporal missile, $44,557, **Gilfillan Bros. Inc.,** 1815 Venice Blvd., Los Angeles, Calif.

Nike-Hercules launching area items, $15,000,000, **Douglas Aircraft Co., Inc.,** 3000 Ocean Park Blvd., Santa Monica, Calif.

Maintenance shop set for Nike-Hercules, $350,000, **Nortronics,** a Div. of Northrop Aircraft, Inc., 500 East Orangethorpe Ave., Anaheim, Calif.

Rocket engines, $1,650,000, **North American Aviation, Inc.,** 6633 Canoga Ave., Canoga Park, Calif.

Military Petroleum Supply Agency, Washington 25, D.C.

Jet fuel, $495,300, **Aurora Gasoline Co.,** 15911 Wyoming Ave., Detroit 38, Mich.; $210,253, **Utility Petroleum Co.,** P.O. Box 7096, Long Beach, Calif.; $367,400, Phillips Petroleum Co., Bartlesville, Okla.; $1,734,200, **Sun Oil Co.,** 1608 Walnut St., Phila., Pa.; $4,436,353, **The Texas Co.,** 135 E. 42 St., N.Y.C.; $2,005,878, **Esso Standard Oil Co.,** 15 W. 51 St., N.Y.C.; $52,725, **Phillips Petroleum Co.,** Bartlesville, Okla.; $271,656, **Standard Oil Co. of Calif.,** Western Operations, Inc., San Francisco, Calif.; $3,129,840, **The Texas Co.,** 135 E. 42 St., N.Y.C.; $207,690, **Tidewater Oil Co.,** 79 Montgomery St., San Francisco, Calif.

New York Ordnance Dist., 180 Varick St., N.Y. 14, N.Y.

Nike spare parts and components, $85,-932, **Western Electric Co., Inc.,** 120 Broadway, N.Y.C.

Evaluation of high resolution missile tracking system, $59,673, **Allen B. Du Mont Lab. Inc.,** 750 Bloomfield Ave., Clifton, N.J.

Philadelphia Ordnance Dist., 128 N. Broad St., Phila., Pa.

Nike spare parts and components, $4,-100,335, **Western Electric Company, Inc.,** 120 Broadway, N.Y.C.

Nike spare parts and components, $193,229, **Douglas Aircraft Co., Inc.,** Charlotte Ordnance Missile Plant, Charlotte, N.C.

Facilities for Talos defense unit, White Sands Proving Ground, $52,745, **Radio Corporation of America,** Moorestown, N.J.

Procurement Office, Aberdeen Proving Ground, Md.

Construction of rocket static firing barricade and a gun and rocket firing barricade, $25,159, **Fidelity Construction Corp.,** 727 Munsey Bldg., Baltimore 2, Md.

San Francisco Ordnance Dist., 1515 Clay St., P.O. Box 1829, Oakland 12, Calif.

End use, guided missiles and related material, $56,000, **Ampex Corp.,** 271 Town and Country Village, Palo Alto, Calif.

Redstone Arsenal, U.S. Army, Huntsville, Ala.

Continued research and development in the field of solid propellant rocketry, $214,800, **Rohm & Haas Co.,** Phila., Pa.

U.S. Army Engineer Dist., Charleston Corps of Engineers, Box 905, Charleston, S.C.

Construction of high altitude training bldg., $67,991, **Boyle Construction Co.,** Sumter, S.C.

U.S. Army Engineer Dist., Corps of Engineers, 2301 Grant St., Mobile, Ala.

Construction of nose cone assembly and check-out facility at Redstone Arsenal, Huntsville, Ala., $155,960, **Perusini Construction Co.,** Birmingham, Ala.

Construction of launcher emplacement area, Redstone Arsenal, Huntsville, Ala., $202,973, **Whaley Co. Inc.,** 6424 First Ave., N. Birmingham, Ala.

Construction of Model II shelters for Bomarc facilities at Eglin AFB, Fla., $231,890, **Greenhut Construction Co.,** 23 S. "A" St., Pensacola, Fla.

U.S. Army Engineer Dist., Corps of Engineers, 111 E. 16 St., N.Y. 3, N.Y.

Construction of jet test cell, Niagara Falls AFB, Niagara Falls, N.Y., $183,799, **Technical Constructors, Inc.** and **B. F. Schoeneman,** P.O. Box 2488, Dallas, Tex.

U.S. Army Ordnance Dist., St. Louis, 1016 Olive St., St. Louis, Mo.

Corporal system repair parts for United Kingdom program, $84,450, **R. G. Le Tourneau, Inc.,** P.O. Box 2307, Longview, Tex.

U.S. Army Ordnance Dist., Los Angeles, 55 S. Grand Ave., Pasadena, Calif.

Repair parts for Nike system, $70,848, **Douglas Aircraft Co., Inc.,** 3000 Ocean Park Blvd., Santa Monica, Calif.

Guided missile, surface-to-surface, $53,-000, **Firestone Tire & Rubber Co.,** 2525 Firestone Blvd., Los Angeles 54, Calif.

Rocket engines, $1,811,000, **North American Aviation, Inc.,** 6633 Canoga Ave., Canoga Park, Calif.

Furnishing and delivering of depot replenishment repair parts for the Corporal missile, $124,919, **Gilfillan Bros. Inc.,** 1815 Venice Blvd., Los Angeles 6, Calif.

Nike-Hercules launching area items, $15,000,000, **Douglas Aircraft Co., Inc.,** 3000 Ocean Park Blvd., Santa Monica, Calif.

Maintenance shop set for Nike-Hercules, $350,000, **Nortronics, Div. of Northrop Aircraft, Inc.,** 500 E. Orangethorpe Ave., Anaheim, Calif.

NAVY

Dept. of the Navy, Bureau of Aeronautics, Washington 25, D.C.

Study and evaluation of in-flight guided missile environmental data, $48,440, **Fairchild Engine & Airplane Corp.,** 1334 N. Henry St., Alexandria, Va.

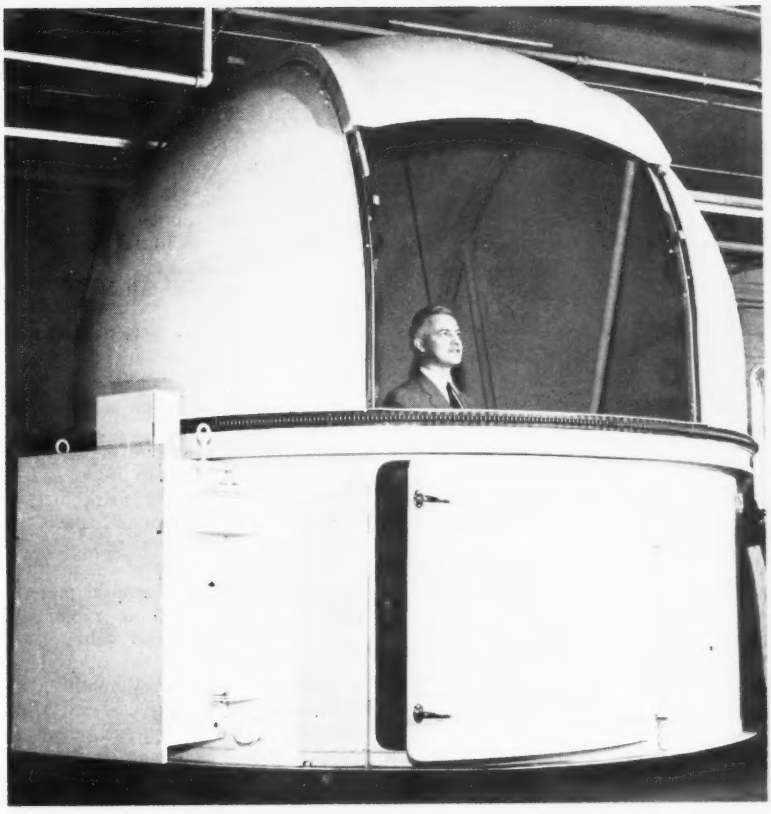
Navy Dept., Bureau of Ordnance, Washington 25, D.C.

Eighty assembled Pogo-Hi targets, less IR sources, and Cajun rocket motors, $152,366, **The New Mexico College of Agriculture and Mechanic Arts.**

Jet engine exhaust noise suppressor, $96,750, **General Ground Control, Inc.,** Los Angeles 45, Calif.

Supply Dept., Naval Air Material Center, Naval Base, Phila. 12, Pa.

Jet engine exhaust silencer, $26,359, **International Aerocoustics Corp.,** 341 Jackson Ave., N.Y.C.



Tracking Dome

Tracking, monitoring and plotting flight paths of missiles, satellites and other space vehicles will be done in Astrodomes like this at White Sands Proving Grounds, N.M. Built by Cook Electric Co., it has a semi-spherical roof that revolves 360 deg and is made entirely of reinforced plastic.

THEORETICAL AERODYNAMICISTS

Heavy experience in boundry layer theory and gas dynamics. Secondary specialty in supersonic and hypersonic flow. Experience must be in missiles; but part of experience may be in supersonic aircraft. Contribution to the field must be substantiated by papers in professional publications. MS required, PhD desirable.

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DENVER

Steps into Space

(CONTINUED FROM PAGE 41)

attractive and perhaps even more essential.

"Flight into space requires that great effort also be devoted to such problems as electronics, guidance and physiology or human factors. We plan to make substantial use, by contract, of organizations with competence already demonstrated in these related fields."

Fortunately, Dr. Dryden pointed out, for the past several years NACA has been reorienting its research effort. "We have shifted much of our powerplant emphasis from air-breathing engines to rocket engine types, which can be used not only to propel ICBM's and satellites, but to send, first unmanned and then manned space craft to the moon and beyond.

"Similarly, the work we are doing on structures and structural materials is now being focused on problems peculiar to missiles and vehicles that travel beyond the earth's atmosphere."

The House Select Committee also heard Dr. Wernher von Braun, ABMA director of technical development and ARS board member, and Herbert York, ARPA chief scientist, avow their general support of the proposed agency. But both felt that NASA would be strapped in handling the present space program by the existing NACA charter, and urged that NASA be given more authority and funds with which to get the job done. They also voiced objections to anything in proposed legislation that would restrict research to projects with immediacy. Such legislation, they said, would rule out research projects such as the million-lb thrust rocket engine for which there will be a future need.

Combat Surveillance

(CONTINUED FROM PAGE 39)

program that manned aircraft available to field commanders might not suffice for surveillance in future warfare. Cost, size, transportability, manpower requirements, vulnerability and logistics were among the factors suggesting that surveillance drones might be profitably employed to supplement manned aircraft for intelligence-gathering missions.

The economical OQ-19B target drone, with minor modifications, was selected for evaluating the usefulness of drones. Modifications consisted mainly of adding a payload compartment to the fuselage, changing the control circuitry of the camera to facilitate "On-Off" operation, and de-

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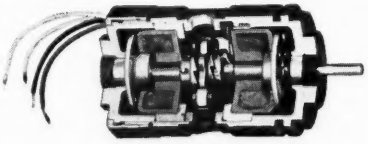

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veloping a zero-length launching system.

It was also necessary to alter a mobile fire-control radar tracking set to provide the tactical navigation data for the drone controller. By adding a variable-scale plotting board and extensive repackaging, the Skysweeper radar satisfied this requirement.

This photographic drone sub-system was suitable for feasibility tests, but evidenced many deficiencies. Drone mission reliability, about 60 per cent during the 1956 test, proved inadequate, payload increases were needed and the drone was highly vulnerable. These deficiencies were not totally unexpected, since many of the factors governing the design of a target drone differ extensively from those appropriate for surveillance.

Subsequent efforts have vastly improved some of these shortcomings. For example, a double-JATO launching arrangement (with the JATO's near the drone CG) advanced launching reliability to nearly 100 per cent. A new control system has been added; nickel-cadmium batteries have replaced lead-acid ones; a larger parachute is being used to decrease landing shock; payload weight and volume have been greatly enlarged; airframe structure has been reinforced throughout; maintenance and pre-flight checkout components have been developed; and more rigid quality control has been instituted for all components.

Tests now under way will evaluate the effectiveness of these changes. If the results are favorable, this drone, now identified as the SD-1, will serve as an economical, reliable test platform, and may also be suitable for interim application in tactical units.

But the nature of nuclear warfare makes necessary surveillance drones with capabilities far surpassing those of the OQ-19 family. Several appropriate R&D projects are in progress for this purpose.

New drones may be expected to have greater operating speeds, increased endurance, larger payloads and many other improved features. The most challenging problem areas encountered in the design of improved models relate to vulnerability both to weapons and electronic countermeasures. Long-range, wide-band, instantaneous transmission of surveillance information presents another formidable obstacle.

Obviously, many other serious problems exist in complex systems of the kind. Diligent efforts by both industry and the military have already brought solutions to many of these problems.

Based on a paper presented at the ASME-ARS Aviation Conference in Dallas, Tex., March 17-20, 1958.

reading the nike psyche

Sherman's ineffective search for phrenic vibrations seems somewhat complicated by the "thoughtlessness" of the lady from Samothrace. (See illustration). Meanwhile, most crainometrical measurement problems are solved in Winged Victory's namesake, the lethal Nike-Hercules, by our Vibrotron® Transducer Systems.

Flight-test engineers at Douglas Aircraft Company have employed these miniature, vibrating-wire devices to sense and signal hydraulic pressure variations in the Nike guidance system and to monitor fuel pressure. Occurring pressure changes cause decreases or increases in the vibrating-wire frequency of the Vibrotron Transducer. Output frequency from a companion subminiature amplifier changes accordingly, delivering via FM/FM telemetry a directly readable digital signal.

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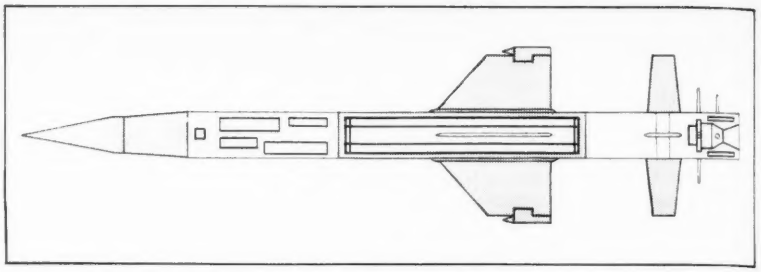
"Do-All" Test Vehicle Serves British Missile Industry

A SINGLE test vehicle, the Short G.V.P., which resembles the Firestreak missile in external appearance, has for several years served all British firms working on guided missiles as a source of research and development information.

The test vehicle has passed through at least six major versions—from a nonpropulsive model for studying aerodynamic performance to a model with a seven-tube aluminum-tank liquid-propellant motor, bottled nitrogen for pressurizing fuel tanks and hydraulic actuators of control surfaces, telemetry package, Elliot homing head and a system of parachutes and flotation bag for landing the missile safely in water.

The test vehicle employs nonintegral construction to accommodate manipulation of its constituents. A solid-propellant boost or sustain motor can be attached to its nozzle end by a blast tube. Wind tunnel tests have described both subsonic pressure distribution and lateral characteristics of boosted and unboosted rounds and supersonic control effectiveness.



Simplified plan view of recovery version of Short G.V.P. Radome and Elliot homing head are forward, followed by section holding tracking repeater, nitrogen storage, buoyancy bag, parachutes, etc. Then come seven-tube propellant tanks and telemetry packages and, finally, actuators, motor and the first-stage parachutes.

Devices tested in the vehicle include longitudinal steel "corset" strips to increase strength, plastic propellant bags to hold high-strength hydrogen peroxide and to control CG shift, a cordite gas generator to pressurize the hydraulic system, high-pressure nitrogen in coiled tubes for the same purpose, a cordite gas generator to expel propellants, two different engines, body structures, explosive actuators and section breakers, radomes, etc.

The Short G.V.P. is presently being used to study homing problems. In addition, more testing is under way of a solid-propellant gas generator for pressurizing propellant tanks.

Space Balls

These three inflatable aluminum foil space balls, said to be able to reflect 80 per cent of sunshine and scheduled for launching some time this year, may permit scientists to track their orbits through astronomical telescopes. The 12-ft sphere (left), expected to be visible to the naked eye at dusk and dawn, was made from $12.56 worth of foil. The 30-in. sphere (foreground), required only 65 cents worth of foil, is held in deflated state by man at desk. At right is a 12-ft diam "contour reflector" that reflects radar waves. All were fabricated for NACA from Reynolds aluminum foil 0.0005 in. thick, similar to that in household use.

Rocket Propulsion for Drones

(CONTINUED FROM PAGE 26)

subsequent flight models have performed equally well.

Thrust chambers of this type can be produced in three basic sizes as off-the-shelf units, and any thrust level within the performance envelope shown in the graph on page 26 and virtually any flight profile can be attained by selecting the appropriate chamber or by multiplying chambers and components.

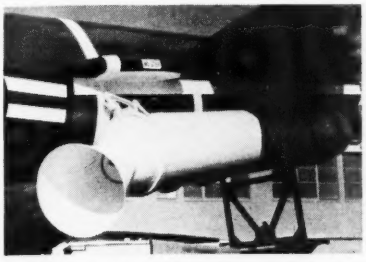
The production cost of a propulsion system of the kind described is surprisingly low. One system produced thus far in only limited quantities sells for well under 2 cents per lb-sec of delivered total impulse. The joint cost of bipropellants is only 51 cents per lb.

All in all, we believe the most significant advance in the field of rocket-propelled target drones is the emergence of the flexible, low-cost, liquid-propellant propulsion system easily adaptable to the foreseeable range of drone flight requirements.

Based on a paper presented at the ASME-ARS Aviation Conference in Dallas, Tex., March 17-20, 1958.

Von Braun Hits Systems Concept As Answer to Space Problems

While the weapons system concept is appropriate in its place and time, it can be a dangerous stumbling block if thoughtlessly applied in our initial efforts to get to outer space, and it has already resulted in "serious delays," Wernher von Braun of the Army Ballistic Missile Agency told a large audience at the Western Space Age Conference and Exhibit in Los Angeles in mid-March.



Solid-propellant rocket on Snark

Dr. von Braun noted that there are definite limitations to the concept as applied to space flight, and that decisions are being held up and funds held back "because we haven't optimized our space systems concept yet."

"I believe we must go full steam ahead even if we don't hit the optimum solution on the first try," he stated. "I'd rather see manned orbital flight in a less-than-optimum-performance vehicle three years from now, instead of having to wait five years to see it accomplished in an optimized design which, alas, is obsolescent because the Russians have again beaten us to the punch."

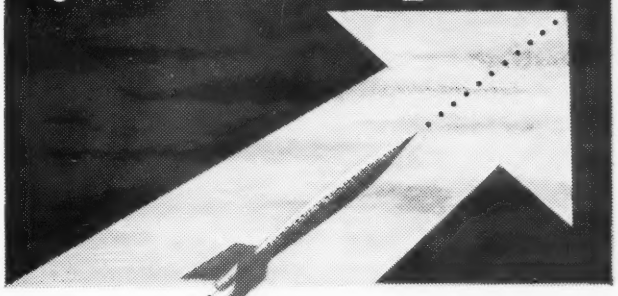
He also pointed out that, despite all the talk about the shortage of engineering talent, a good many engineers and scientists are not utilized full time because of slack periods between major projects handled by their companies, reorientations caused by military and operational considerations and project cancellations.

His address was one of the highlights of the conference, sponsored by the Los Angeles Chamber of Commerce, and featuring a full-scale missile exhibit at the Shrine Exposition Hall.

New Rheem Drone System

A new all-weather surveillance drone system utilizing the SD-2 drone has been designed and developed by Rheem Mfg. Co. for the Army. The SD-2 is zero-length launched from a launching vehicle, using a rocket assist, and is expected to be recoverable by parachute.

Reliability . . . in advanced weapons systems requires



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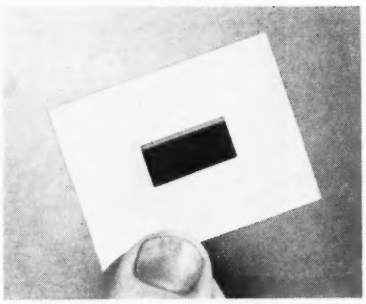
Solar Power Operates Satellite Radio Transmitter

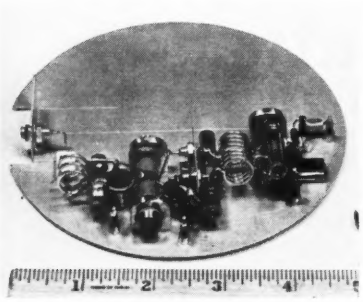
Ruggedized silicon solar energy cells designed to withstand extreme environmental conditions encountered in missile launching and outer space travel have been developed by the Semiconductor Div. of Hoffman Electronics Corp. The cells are used in the Navy's Vanguard satellite, which has one of its radio transmitters operating on direct solar power assemblies.

The Type SS cells are of the silicon P-N junction type, with average conversion efficiencies of 8 per cent, based on a solar constant of 1400 watts per square meter of collecting area under standard testing conditions, and will operate indefinitely at peak efficiency.



The cells will be available in quantities of single elements, 1 by 2 cm, or connected in any desired voltage and current combination.

Efficiency of Satellite Radio Doubled



Miniature broadcasting station, designed to fit into a satellite or missile, weighs 3 oz yet develops 500 milliwatts of power.

Future U.S. satellites will be able to broadcast data four times as long as is presently possible, as a result of the development of a transmitter by the DuKane Corp., St. Charles, Ill., under an NRL contract. The transmitter was developed as a 500-milliwatt version of NRL's 100-milliwatt satellite transmitter.

The crystal-controlled transmitter employs three recently developed Western Electric transistors capable of operating as oscillators or amplifiers at 108 mc. Special circuits give greater overall efficiency than is now possible with vacuum tubes.

The transmitter weighs less than 3 oz, occupies less than 6 cu in. of space and operates on a 24-v battery.

The transmitter can be operated on solar batteries, drawing its power from the sun and sending out its signals indefinitely, but with one-half to one-fourth of the rocket surface heretofore required for sun exposure. The output stage of a conventional tube-type transmitter doing the same job would need 4620 milliwatts power to produce 500 milliwatts. By contrast, the new transmitter needs only 930 milliwatts power to produce the same output.

•

Cam-Piston Air Motor: For operation at temperatures over 1000 F with no conventional lubrication or cooling, an air motor has been developed as a power source that can withstand the extremely high temperatures found in missile and supersonic flight at speeds of Mach 2 and beyond. The motor is a positive displacement, fluid driven power device that uses hot compressed air. Gearless, it is being produced in three sizes varying in length from 9 to 13 in. AiResearch Mfg. Div., The Garrett Corp., 402 S. 36 St., Phoenix, Ariz.

•

Miniature Accelerometer: The A52 accelerometer, utilizing the unbonded strain gage principle, has dimensions of 0.32 by 0.35 by 0.97 in., and weighs 7.2 g. Laboratory calibration makes it especially suited for missile guidance systems, within control surfaces for vibration studies on aircraft or missiles, within wind tunnel models, or for other applications having critical space limitations. Statham Instruments, Inc., 12401 W. Olympic Blvd., Los Angeles 64, Calif.

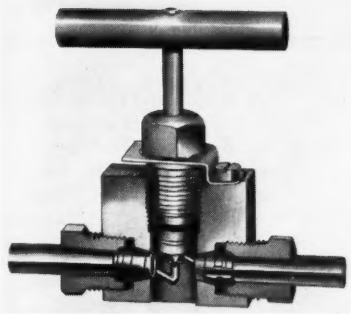
•

Commutator Switches: A complete line of newly designed, long-life commutator switches is available. Motor-driven units are used in telemetering, sampling and programming applications. Designed for a minimum life of 500 hours, and for switching of high- and low-impedance circuits in aircraft and missile applications, the commutators are made in a wide selection of poles and positions, and in speeds from $^1/_8$ to 30 rps. Pacific Div., Bendix Aviation Corp., 11600 Sherman Way, N. Hollywood, Calif.

Micro Projector: The Scherr projector features a vertical principle of design offering these advantages: A horizontal stage onto which flat work is laid without fixtures or holding devices; an inclined screen on which the enlarged image is reproduced directly in front of the observer; and a choice of fixed standard magnifications that are changed by slipping different projection lenses into a vertical socket in which they rest by gravity. When using the micrometer cross slide, both measuring motions are performed on the horizontal plane. George Scherr Co., 200 Lafayette St., New York 12, N. Y.

•

Memory Meter: A device that retains indefinitely a reading taken at any desired instant has been developed for applications where readings at a given time cannot be noted immediately. Such situations include remotely located meters or batteries of meters with a number of different but related readings. The "memory meter" is available in almost any sensitivity range, from a few microamperes or millivolts to 50 amp or 500 v, either ac or dc. Assembly Products, Inc., Chesterland, Ohio.



High-Pressure Valves and Fittings: A line of "quick-connect" valves and fittings for high-pressure set-ups to 10,000 psi is now available. Made of stainless steel, these products are designed to reduce set-up time, with no threading or beveling required. American Instrument Co., 8030 Georgia Ave., Silver Spring, Md.

•

Printed Circuit Assembly: Reduction in size and weight for microwave transmission systems is the result of a broad band Strip-Line assembly package. Using a sandwich-type construction, printed circuitry has been adapted to produce microwave "plumbing" that is said to reduce weight by 60 per cent and space requirements by 65 per cent over folded configurations. Kearfott Co., Inc., Western Div., 14844 Oxnard St., Van Nuys, Calif.

PRODUCT LITERATURE

Multicoder Type GLH-2 (Catalog G-1000). Monitorscope model CMS-2 (C-1000). Sweep Generator model CSG-2 (C-1025) and Junction Box model CJB-1 (C-1050). Applied Science Corp. of Princeton, P.O. Box 44, Princeton, N. J.

Molded and Laminated Plastics for industry and defense. The Richardson Co., 2700 Lake St., Melrose Park, Ill.

High Temperature Ceramic Materials. Duramic Products Div., Technion Design & Mfg. Co., Inc., 262 Mott St., New York 12, N. Y.

Screen Room Filters Catalog FSR-1200 for R. F. interference suppression. Filtron Co., Inc., Flushing, N. Y.

Standard Definitions For Snap-acting Switches recently adopted by the NEMA. Hetherington, Inc., Folcroft, Pa.

Subminiature Absolute Pressure Switch Model RR-30 Bulletin. Newark Controls Co., Bloomfield, N. J.

Mod IV-C and Mod III Multidata Cameras. Flight Research, Inc., P.O. Box 1-F, Richmond 1, Va.

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Once Round the Sun—Story of the International Geophysical Year, by Ronald Fraser, The Macmillan Co., New York, 160 pp., illustrated. $3.95.

The citizen of the world who wishes to keep informed on the major endeavors of man will want to enter this little book on his reading list. In "Once Round the Sun," Ronald Fraser describes the world's greatest cooperative scientific undertaking of all time, the International Geophysical Year.

The author's text is divided into two parts. Part I deals with what is known about the earth and the sun, describing in turn the earth itself, its climate and weather, the ocean, our upper atmosphere and the sun. In this portion of the book, the author takes pains to tell not only of what the scientists know or think they know about the earth and sun, but also to bring out the many problems that still remain to be solved.

The second part of the book is devoted to the International Geophysical Year itself. Running from July 1, 1957 to Dec. 31, 1958, the formal program of the IGY will occupy the attention of scientists in countries all around the world while the earth goes once around the sun and then half around again. The author tells how observations in such disciplines as meteorology, the ionosphere, aurora and airglow, cosmic rays, geomagnetism, solar activity, gravity, seismology, latitudes and longitudes, oceanography and glaciology, will help solve many of the major problems of geophysics and solar physics. Considerable attention is devoted to the challenging efforts in the Antarctic and with rockets and satellites.

The author, a scientist himself, brings to the task of writing his tale both an understanding of the subject and skill in writing—a combination that produces a highly readable account. The good typography and the fine illustrations add to the reading pleasure. The reader should be alerted to the fact, however, that in this fast-moving program, there have been some changes since the author assembled his information. An additional 10 countries have joined the program since Fraser made his count of 54. Also, although the author's description of the rocket and satellite program is substantially correct, a number of details have changed in the course of the program.

It must be clear to all that the activity that IGY has started will not end with the termination of the formal IGY period at midnight of Dec. 31, 1958. The dividends will continue to accrue throughout the years to come. Fraser's book serves as an excellent introduction to the book about IGY results that someone should write several years from now.

Homer E. Newell Jr.
U.S. Naval Research Laboratory

Project Satellite, edited by Kenneth W. Gatland, British Book Center, New York, 1958, 168 pp., illustrated. $5.00.

This is a curious book, made up of four fairly lengthy essays by one American, Wernher von Braun, and three British astronautical engineers—Kenneth W. Gatland, Harry E. Ross and A. V. Cleaver. Written before successful satellite launchings, the volume has a dated quality despite superficial attempts to make it more timely by brief references to recent developments in Gatland's introduction and in his contribution.

The first chapter, an "as told to" contribution by von Braun, is actually nothing more than a 30-page autobiography, offering little more on satellites than the suggestion that the Peenemuende A-9/A-10 project might have developed into a satellite launching vehicle through the addition of a third stage. This section is primarily a description of the early days of rocketry in Germany and of Peenemuende, seen through the eyes of one who played an important role in these activities.

Gatland's chapter offers a rundown on the background and history of the U.S. satellite effort, but is confined to the Vanguard project, which is described in detail. Jupiter-C is polished off in a brief footnote, while the two Sputniks are covered in only four pages.

By far the most interesting parts of the book are those contributed by Ross and Cleaver. The former, in his chapter on "Orbital Bases," provides an engineer's appraisal of the various types of manned satellite stations now in the planning stages—satellites serving as radio and TV relay stations, as weather stations, astronomical observatories, etc. He also offers a rundown on the problems involved in providing an artificial atmosphere, food and water, and protection against cosmic radiation and meteorites for such stations.

Cleaver's chapter on interplanetary flight is a stimulating one which goes still farther into the future, dealing with the use of satellites as orbital refueling stations, the various types of propulsion systems and vehicles that will be used for space flight, the motivation for interplanetary exploration and even the estimated cost of various projects.

Some minor errors have crept into the text (Example: "General F. Twining" for Nathan F. Twining, page 69) and, while the book is profusely illustrated, offset printing has in some cases reduced photographs almost to smudges.

Summing up, "Project Satellite" might well prove of interest to the layman, but has little to offer people working in the field. —**I.H.**

BOOK NOTES

Astronauts with and without children will get a boot out of **"The Space Child's Mother Goose"** (Simon & Schuster, $3.50), a collection of verses, based to a large extent on well-known nursery rhymes, by Frederick Winsor, whimsically illustrated by Marian Parry. While the author has a tendency to go a long way for a gag, some of the verses are brilliantly written parodies, and the illustrations alone are worth the price of the book. Summary: Despite its title, definitely *not* for children, but as good a gift as you'll find anywhere for a space-minded friend. —**I.H.**

In **"Around the World in 90 Minutes"** (Harcourt, Brace, $5.75), David O. Woodbury, a writer of note on scientific, engineering and industrial subjects, turns his attention effectively to earth satellites. This well-written volume is an absorbing account, and any general reader can benefit from the author's erudition and reportorial ability. Written for the most part before Sputnik I, the book deals primarily with the Vanguard project. The first chapter, written after completion of the other text, gives the then-available facts about the first Sputnik, and other references to it are introduced throughout the book. —**G.E.P.**

Lloyd Mallan's **"Secrets of Space Flight"** (Arco, $2), originally published in 1956 as a soft-cover book, has been given hard covers and reissued as a "new" book on the subject. Of interest primarily for its coverage of the human factors in space flight, the volume, although less than two years old, appears quite dated in the light of recent developments.

Conquering Space

(CONTINUED FROM PAGE 20)

a procedure is the height of foolhardiness. Our insistence on completely demonstrable military justification is the prime reason why we were not the first to launch an ICBM, and why our intermediate range ballistic missiles are still in the experimental stage while the U.S.S.R. reportedly has operational squadrons in the field.

The situation is analogous to that of a businessman who insists on a proven market for a given product before engaging in its manufacture. In a competitive situation, such insistence would be fatal, for once the market situation is obvious, even the dullest competitor will recognize it and be in full production. In commerce, less obvious and sometimes intuitive methods mark the successful executive. Buying trends, histories of similar products, classification of the product as fundamentally new or merely a minor innovation or design change—all affect the decision. These considerations are far from concrete, but are the foundations for successful product selection.

Although such reasoning is common in business, it has seldom been applied in weaponry. This conservatism is reflected in the old adage that the next war always begins with the weapons of the last one. The people have never sufficiently trusted the wisdom of even their most farsighted leaders to permit such gambling with public funds.

We can no longer afford this luxury of leisure. The increasing pace of science and the ever-growing importance of new weapons are making the ultraconservative approach as fatal in war as it is in peace.

We must use every available means for predicting the proper direction for weapons development. We must use both analysis and analogy. We must select research and development leaders with a record of having been right—and then support their judgment.

The measures being proposed today to catch up with Russia in the ballistic missile field are those we should have taken yesterday. These measures are necessary, but we must not neglect, in addition, to make today the decisions that must be made today to avoid being late tomorrow. Many of these decisions relate to the new science of astronautics.

In the field of space flight, the situation is very fortunate in one respect. Quite independent of military implications, the people of the U.S. want to undertake the conquest of space, in the broadest sense. No other

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venture in modern times has so captured the imaginations of men in all walks of life. Here is a chance to proceed without fear of general criticism in a field which stands all the basic tests for ultimate utility except that of detailed proof. Such acceptance offers the opportunity for wise leaders to insure superiority of this nation in a new field as significant as flight through the air or transportation over the water.

Astronautics, this science of flight through airless space, is no mere innovation. It offers not only a different way to reach old places, but a means of reaching places unattainable by other routes. It conforms to the historical trend that man has always sought, and found, means to travel higher, faster, further. That only a limited number of concrete military applications have as yet been uncovered is only an outgrowth of our own limited vision. We have difficulty in adjusting our thinking to an environment in which space travel is commonplace.

In the light of the new environment that astronautics itself will create, the utilities will appear. The importance of all previous great developments, particularly those in transportation, has been imperfectly appreciated in the beginning. Witness the ridicule heaped on the early steamboat, locomotive, automobile and airplane.

Many Benefits Will Result

Many benefits will result from a wholehearted determination to conquer space. The first, oddly enough, is that we shall probably get our military space vehicles cheaper than we would if we developed them, project by project, as applications become clear. The reduced cost will result from the mutual support possible when an overall plan is followed.

In addition, we would see many commercial benefits—world-wide television using satellite relay stations; improved weather service and hurricane warning systems; and, ultimately, faster surface-to-surface transportation. Most of all, however, we shall participate in the greatest adventure of all times, the exploration of the universe.

No, our pyramiding efforts to answer the Sputniks with more missiles, more aircraft, more weapons of all kinds, will not give us mastery of space. Satellites, both manned and unmanned, moon rockets, interplanetary probes and manned expeditions are required. If the Russian program includes these items, as they say it does, it is they, and not we, who will be the masters of space, and they, and not we, who will reap the foreseeable benefits.

More than that, they will reap the *unforeseen* benefits that invariably stem from new knowledge. Just as nations could never control the seas, nor even protect their shores with coastal batteries, neither will we be able to protect our land from an enemy who controls the space a scant 200 miles above it.

If this country fails to heed the providential warning of the first scientific Sputniks, it will not be the fault of our citizens. There can be no question that they are not only willing, but eager, to bear whatever costs are necessary. The blame will rest squarely on our leaders in government who fail to appreciate the full significance of this opening of a new age.

The Necessary Elements

Certain elements are necessary if we are to establish a position of leadership in astronautics. Among these are: First, a national determination to do so, expressed in terms of adequate, stable financing; second, an organization clearly charged with the responsibility for developing space flight in all its aspects, and preferably

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an organization having this as its sole mission; and, third, manning of this organization by competent, dedicated individuals personally interested in the conquest of space.

At present, the United States has no integrated space flight program. It is not planning one. Russia does. That program is now beginning to bear fruit, and it will continue to bear fruit. We cannot overtake the U.S.S.R.—in fact, we cannot even catch up—with half-hearted, piecemeal efforts.

Even with the creation of an Advanced Research Projects Agency in the Defense Department and the establishment of a National Aeronautical and Space Agency, it appears that what is being planned is a collection of projects, a number of stunts with existing equipment, rather than a correlated program to develop the building blocks which are common to nearly all serious space missions.

Among these building blocks are: A maximum-energy final stage for Atlas or Titan; a lightweight electrical power supply system with long endurance qualities; a lightweight inertial guidance system; a means of recovery of first-stage booster rockets; low g re-entry systems; and a new, large, high-performance, recoverable booster for use after present ICBM's have been fully exploited.

These are the elements which will give us space superiority, not putting a beer can on the moon. A program planned and integrated through third or fourth tier sub-systems can only be carried out by people having space flight as their sole mission and by individuals who understand the many problems involved.

In this respect, we must realize that aeronautics is not astronautics. True, certain of the techniques of aeronautics are applicable to astronautics. For example, certain aspects of aerodynamics will be common to aerial flight and the take-off and re-entry portions of space flight, but it would be no more logical to couple astronautics with aeronautics because of this feature than it would have been to tie aeronautics to automotive transportation because the airplane spends a portion of each flight rolling along the ground on rubber tires.

Recognition as New Science

Astronautics must be recognized as a new and separate science. The more quickly this is done, the sooner its development will be freed from earthbound or airbound thinking. Existing aeronautical organizations are not equipped, either in the majority of their facilities or in the majority of their experience, to do justice to the

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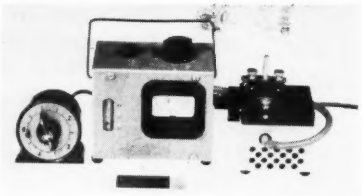

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development of space flight.

Consequently, combining aeronautical and astronautical projects in one agency, as the President has proposed, could be fatal to a national space flight program if aeronautical men hold the top posts in such an agency and aeronautical thinking is predominant.

Astronautics excites the imaginations of men as few other scientific endeavors ever have. It draws devoted savants eager to participate in a venture that history must inevitably regard as a major landmark in the progress of civilization. If the execution of a comprehensive space flight program is placed in the hands of such enthusiasts, there can be no question of waste or duplication.

Dozens of such dedicated and well-qualified enthusiasts are available. These are not the Johnny-come-latelies who have been literally crawling out of the woodwork since Sputnik I, but men of vision and ability, long experienced in rocket science.

If key management posts are held by such individuals, they will spend appropriated money as they would their own—in such a fashion as to achieve maximum results, rather than a maximum of personal or organizational aggrandizement. However, their charter must be clear and firmly stated, in a manner that leaves no room for modification or retraction. If fussily drawn or timidly enforced, political squabbles and distraction of effort will inevitably result.

The exact form of organization is of small consequence. The quality of the personnel and the clarity of their assigned mission are of paramount importance.

Without a clear-cut national resolve to lead in the exploration of space, and centralized planning and direction, we not only will not overtake the Russians, but the gap will continue to widen until they are as truly masters of space as England was master of the seas in the last two centuries.

And, lest we be dazzled by our own recent successes, let us remember that we could fire Vanguards and Explorers for the next 20 years at approximately the same rate and still not have the payload in orbit that was carried in Sputnik II alone.

Great caution and deliberation might be necessary if the costs involved were a major fraction of our current arms budget. Such expenditures are not required. If a sustained, well-integrated program is pursued, free from the fits and starts, and the constant acceleration, deceleration and redirection that characterize our weapons programs, the cost will barely be noticeable to the average

taxpayer. An allocation of 2 per cent of our current arms budget to space conquest would support a handsome program.

This small amount could easily be saved by reduction in some of our obsolete arms, by ceasing production of obsolescent ones, and by eliminating the senseless duplication of many short-term but very expensive weapons. Above all, it could be saved by unified long range planning and constancy of effort.

At the present time, as we are painfully aware, it is not ourselves, but the Russians who are blazing trails in this new realm. It is not the country best able to afford a noble gesture to the furthering of science, but one of the least capable of so doing. It is not a country that prides itself on its love of peace and traditional unpreparedness for war that is squandering its resources on such unprofitable endeavors, but a frightened, bitter, aggressive country perpetually laboring under an arms burden too big for its economy. It is not a country that prides itself on its pioneering spirit that is pursuing this last frontier, but a country with a background of slavery and oppression.

Military Projects Dominate

One of the reasons we are lagging in this exploration of space is that we refused to allow such scientific efforts to interfere in any way with our military ballistic missile effort. Our preoccupation with purely military projects does not do justice to our world position, nor to our pioneering traditions.

It is perhaps fitting that the military applications of space vehicles are not yet overwhelmingly obvious. Thus a nation interested only in military advantage might ignore the challenge, while one interested in advancing civilization to a new and grander age could only respond with vigor and enthusiasm. So far, the reaction of the U.S. is far from reassuring.

America, which will it be?

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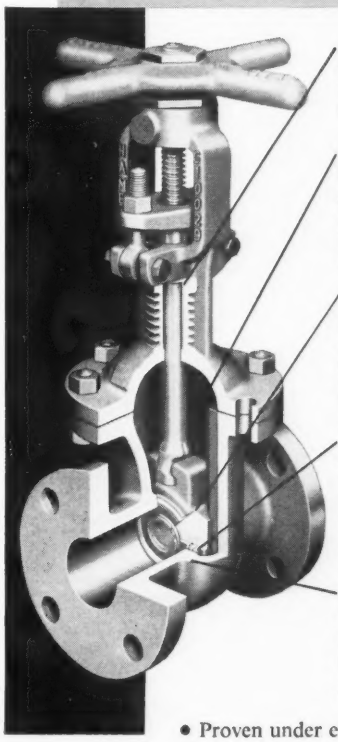

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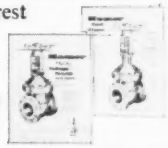

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